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CALCULATION OF DENSITY AND SPECIFIC GRAVITY DATA FOR CONTAINER GLASSES: CORRECTIONS FOR TEMPERATURE AND AIR BUOYANCY

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There is considerable ambiguity and confusion in the glass industry in the reporting of density and specific gravity values. The need for uniform methods for calculating these values is very apparent. Much of the confusion arises because various and uncertain corrections are made for the changes of density and of specific gravity with temperature. When weighing techniques are used, the buoyant effects of air on the samples and balance weights are too often neglected. This present memorandum discusses in detail the effects of temperature and of air buoyancy on density and specific gravity. Practical factors are presented that provide the necessary corrections for these effects, and complete calculations are given to illustrate the use of these factors. All calculations and factors are based upon the thermal expansion and density values found in commercial "soda-lime-silica" container glasses. Similar factors can be easily derived for any other type of glass.

Definitions, Units and Methods

Density is defined as mass per unit volume and can be expressed, therefore, in any units for mass and for volume. For example, pounds per cubic foot or pounds per gallon are frequently used in the English absolute system of units. The metric units employed are grams for mass, and milliliters or cubic centimeters for volume. The milliliter is a unit defined on a true volume basis, whereas the cubic centimeter is based on a length standard and is not *defined* as a volume unit. These two units were originally intended to be equal, but discrepancies in the original measurements precluded this equality. One milliliter is equal to 1.000027 cubic centimeters. In glasses with densities between 2.4 and 2.6, the difference between the density expressed in gm./ml. and that expressed in gm./cc is about 0.00007 in numerical value, the gm./ml. value being the larger. When density values are rounded off to four decimal places this difference may or may not appear; e.g., the equivalent values of 2.50014 gm./ml. and 2.50007 gm./cc. would each be expressed as being equal to 2.5001 units, whereas, values of, say, 2.50017 and 2.50010 would show this difference, being reported as 2.5002 gm./ml. and 2.5001 gm./cc., respectively.

Specific gravity is the ratio of the density of the unknown at a particular temperature to the density of a standard substance at the same or some other temperature. Usually, pure water is used as the standard substance. The specific gravity of glass at a temperature of T° with respect to water at T°, usually termed the T°/T° specific gravity, is the ratio between the absolute density of the glass and that of pure water, both at T° and both expressed in the same density units. For example, since the density of water at 20° C* is 0.9982 gm./cc., a glass having a density of 2.5000 gm./cc. at 20° will have a 20°/20° specific gravity of 2.5045.

In order that density, or specific gravity, values may be compared with each other, they should represent their respective glasses at some standard temperature. In this laboratory, density is expressed in gm./cc. for the glass at 20°. The 20°/20° specific gravity is used; that is, the specific gravity of the glass at 20° with respect to water at 20°. The specific gravity of the glass at the temperature of measurement, T°, can be determined directly by the Archimedes method; the weight of the glass in air is simply divided by its loss of weight in water. Multiplication of this T°/T° specific gravity by the density of water at T° yields the density of the glass at T°. The correction of this figure to that for the glass at 20° is discussed fully in the following section of this paper. In contrast to this procedure, the 20°-density can be found directly, through comparison of the glass with a standard glass of known 20°-density. This can be done by any one of a variety of sink-float techniques utilizing heavy-liquids mixtures. From this density and that for water also at 20°, the 20°/20° specific gravity then can be calculated. The section below on Sample

*All temperatures are expressed in degrees centigrade unless otherwise indicated.

Calculations discusses each of the above calculations in detail.

A common plant practice has been to calculate the T°/T° specific gravity of the glass at the temperature of measurement. This T°/T° specific gravity has then been corrected to a so-called "20°/20°" value by means of a constant "correction factor." As is discussed further below, such a factor can hold quite closely over a temperature interval from about 18 to 26°, if chosen correctly.† However, it rapidly falls into error outside of this range.

In the Archimedes method, the buoyant effects of air upon the glass and the brass weights are very appreciable. The usual weights of the samples of container glasses, densities from 2.4 to 2.6 gm./cc., lie between 10 and 30 gms. For these specimens the uncorrected densities and specific gravities are 0.0017 to 0.0019 units greater than the true values. Most laboratories customarily omit these corrections on all samples. Since the corrections have an almost constant value, their omission does not affect the comparison of these uncorrected values. In these cases, however, it is well to remember that the reported values are 0.0018 ± 1 units greater than the true densities.

If the Archimedes method is used, the temperature of measurement may range, in extreme cases, from about 10°(50° F) to 38°(100° F), but it is usually between 18°(64° F) and 28°(82° F). With the techniques involving heavy-liquids mixtures, either sink-float in a water-bath or balance in the stroboscopic centrifuge, the temperatures of measurement may be between about 10°(50° F) and 50°(122° F). In these temperature ranges the thermal expansions of ordinary glasses are linear. Hence, for each glass the temperature-coefficient of density, being related only to this expansion, is a constant for these temperatures. In contrast with this, the specific-gravity coefficient is not constant; the thermal expansion of water is far from linear, and this irregularity enters into the specific-gravity coefficients. Therefore, for a particular glass (or similar glasses), a single density-coefficient can be used over the whole pertinent temperature range. However, no particular factor for specific gravities will hold with precision outside its corresponding temperature range of about 8 degrees.

Variation of Glass Densities with Temperature

The relationship between the temperature coefficient of density and the absolute density can be expressed in terms of the volume-coefficient of thermal expansion as shown in Equation (1).*

$$dD/dT = -\beta D_T$$

where dD/dT = temperature coefficient density
β = volume coefficient of thermal expansion
D_T = density of the glass at some temperature T.

By means of Equation (1) the values of dD/dT can be calculated for a glass having any particular pair of D_T and β values. Comercial bottle glasses have densities in the range from 2.45 to 2.55 gm./cc. The linear coefficients of thermal expansion, α, for these glasses lie well within the range from 80×10^{-7} to 100×10^{-7} per °C. The volume coefficients of thermal expansion, being equal to 3α, have values between 240×10^{-7} and 300×10^{-7} per °C. The results of the calculations by Equation (1) for the above ranges of properties are summarized in Table I.

TABLE I

Values of dD/dT for Various Pairs of β and D_T

($\alpha \times 10^7$), per °C	80	85	90	95	100
($\beta \times 10^7$), per °C	240	255	270	285	300
Density, gm./cc.	($-dD/dT \times 10^6$), gm./cc./°C				
2.45	59	62	66	70	73
2.47	59	63	67	70	74
2.50	60	64	67	71	75
2.53	61	65	68	72	76
2.55	61	65	69	73	76

From Table I it is seen that commercial bottle glasses can be well represented by a temperature-coefficient of density equal to -0.000070 ± 5 gm./cc./°C. Although a coefficient of -0.000060 ± 5 may fit certain low-density, low-expansion bottle glasses somewhat better than the -0.000070 ± 5 factor, such improvement is too small to be significant. Therefore, the coefficient to be used for the variation with temperature of the density of ordinary "soda-lime-silica" container glasses is:

$$dD/dT = -0.00007 \text{ gm./cc./°C} \qquad (2)$$

This coefficient is to be applied directly to the density of the glass found at the temperature of measurement. Since it is a function only of the expansion and density of the glass in question, it can be used on density data obtained by any of the various possible techniques. For each temperature of measurement, the corresponding correction applies to all of the commercial glasses under consideration. In order to convert the density, D_T, at the temperature of measurement to that, D_X, at the standard temperature of 20°, Equation (3) below can be used.

$$D_X = D_T + 0.00007(T - 20.00) \qquad (3)$$

The values in Table II have been calculated by Equation (3) for the standard temperature of 20°. In the table the actual temperature interval in which the temperature of measurement falls is given for each 0.0001 change in the net density correction.

†See also: Anon., "Glass Composition Control by the Use of Specific Gravity Determinations," Glass Industry 22 (9) 384-386 (1941).

*Derivation of Equation (1)

Let the following values hold for a piece of glass:

	At Temperature of $(T)°$	*At Temperature of* $(T+1)°$
Mass	M	M
Volume	V_T	$V_{T+1} = V_T(1+\beta)$
Density	$D_T = \frac{M}{V_T}$	$D_{T+1} = \frac{M}{V_T(1+\beta)} = \frac{D_T}{1+\beta}$
dV/dT	β	β

$$\text{Then, } dD/dT = D_{T+1} - D_T = \frac{D_T}{1+\beta} - D_T =$$

$$-\left(\frac{\beta}{1+\beta}\right) D_T$$

Now β is small compared with unity, so β can be substituted for $\frac{\beta}{1+\beta}$.

Hence $dD/dT = -\beta D_T \qquad (1)$

TABLE II

CORRECTIONS FOR CONVERSIONS OF DENSITIES TO 20°. BASED ON TEMPERATURE COEFFICIENT OF —0.00007 GM./CC./°C

Temperature of Measurement T°C, lies between:	*Net Correction (gm./cc.)*
9.29-10.71	—0.00007
10.72-12.14	6
12.15-13.57	5
13.58-15.00	4
15.01-16.42	3
16.43-17.85	2
17.86-19.28	—0.0001
19.29-20.71	0.0000
20.72-22.14	+0.0001
22.15-23.57	2
23.58-25.00	3
25.01-26.42	4
26.43-27.85	5
27.86-29.28	6
29.29-30.71	+0.0007
30.72-32.14	8
32.15-33.57	9
33.58-35.00	10
35.01-36.42	11
36.43-37.85	12
37.86-39.28	13
39.29-40.71	+0.0014
40.72-42.14	15
42.15-43.57	16
43.58-45.00	17
45.01-46.42	18
46.43-47.85	19
47.86-49.28	20
49.29-50.71	+0.0021

Variation of Glass Specific Gravities with Temperature

As mentioned previously, the specific gravities do not change linearly with temperature because of the non-uniform thermal expansion of water. The density of the glass and the coefficient of expansion of the glass also influence the specific-gravity coefficients. In Figure 1 (see page 199) the variation with temperature of the specific-gravity correction, necessary to yield the standard 20°/20° specific gravity, is shown for temperatures of measurement ranging from 10 to 50°. These results were calculated on the basis of a glass of 2.5000 gm./cc. density at 20.00° with a —0.00007 gm./cc./°C temperature coefficient of density. They hold, however, to a high degree of accuracy for all the glasses under consideration. For all these glasses, the curve of Figure 1 gives the corrections with a maximum error of 0.0001 for temperatures between 15 and 25°. Between 10 and 15° and between 25 and 30°, the maximum error is 0.0002. This curve, therefore, fits the glasses in question to within the experimental errors involved in the density measurements. The correction for any particular temperature, T°, is to be added algebraically to the T°/T° specific gravity of the glass at that temperature.

The curve of Figure 1 can be approximated by a series of five straight lines, none of which deviates at any point by more than 0.0001 from the curve. For each temperature interval, the correction is then given by an equation of the type:

$$c = a' + b(T - 20)$$
$$\text{or } c = a + bT \qquad (4)$$

where c = specific-gravity correction
T = temperature of measurement
b = slope of line
a′ = intercept of line on 20° abscissa
a = a′ — 20b

The values of a and b are given in Table III for the temperature intervals under consideration.

TABLE III

LINEAR APPROXIMATIONS OF CURVE FOR TEMPERATURE-CORRECTIONS TO 20°/20° SPECIFIC GRAVITY

Temperature of Measurement, T°C, lies between:	a	b
11 and 18°C	0.0063	—0.00030
18 and 26	0.0099	—0.00050
26 and 34	0.0151	—0.00070
34 and 42	0.0201	—0.00085
42 and 50	0.0264	—0.00100

The values in Table III can be used in Equation (4) for calculation of the specific-gravity corrections. These will give the corrections within a maximum divergence of 0.0001 from the curve of Figure 1. For example, the correction for 25.4° is —0.0028 as read from the curve of Figure 1. Substitution of the appropriate values in Equation (4) also yields a correction of —0.0028, as follows:

$$c = 0.0099 - (0.00050 \times 25.4)$$
$$= 0.0099 - 0.0127$$
$$c = -0.0028$$

Sample Calculations

The following examples are shown as a guide in the application of the corrections discussed above. They include complete calculations for both density and specific gravity, with and without the corrections. For an actual determination in a plant laboratory, obviously, only those steps that are desired would be considered. Items having the letter d preceding their numbers are necessary in the calculation of densities. The letter s denotes those steps leading to the specific gravity of the sample.

(A) ARCHIMEDES METHOD

Method: Samples ranging from 10 to 30 gm. in weight are weighed in air, and in water at a known temperature, T°.

Data: Three weighings are made; the weights recorded are those read directly on the balance, without any corrections other than those, if any, on the values of the balance weights used.

s, d	(1) Weight of glass in air	22.0147 gm.
s, d	(2) Weight of glass and basket in water at T°C	16.7208 gm.
s, d	(3) Temperature of water, T°	24.3°
s, d	(4) Weight of basket in water at T°	3.5002 gm.
d	(5) Density of water at T° (From Handbook)	0.9972 gm./cc.

(*Continued on page* 198)

HARTFORD-EMPIRE DEVELOPS INSPECTOR FOR FINISH CHECKS

One of the latest developments of the Hartford-Empire Company is a fully automatic jar inspecting device known as the Hartford 74 Check Inspector. This new unit, the first of a series of automatic inspection equipment now under development, has been made possible through the utilization of an electronic system perfected by the General Electric Company.

The reasons for the appearance of finish checks in glass containers are too well known to the industry to require detailed elaboration. However, it may be mentioned that while all finish checks are not inimical to perfect sealing, the orientation of others when occurring on the part of the finish which comes into contact with the gasket of closures designed for vacuum sealing have a tendency to dissipate the vacuum within a short period of time. It is for the detection of this type of defect and its elimination from the packing table that the Hartford 74 Check Inspector was evolved.

Present methods of visual inspection are the remnants of the era of the cork stopper and are obviously inadequate to present and future requirements. To meet today's demands and to insure the glass container against the encroachment of competitive materials after the war, glass must offer the highest possible functional qualities. In the specific matter of efficient vacuum sealing in glass, a container must be capable of forming part of a dimensionally exact assembly with cap and gasket to produce the desired final result of a hermetically sealed package.

The usual method of hand inspection is to have approximately one packer for every thirty containers coming through the lehr per minute.

Defects in glass containers may be classified into a number of varieties running to thirty or more depending on the meticulousness of the classifier. At the rate of packing mentioned above, the packer has just two seconds per container to inspect and pack it. To recognize, decide, and reject a container for any one of the thirty or more varieties of defects, under such conditions, is obviously a major feat of human observation. This is particularly true since certain of these defects, such as checks, are exceedingly minute and are visible only at certain orientations to the incident light while other defects, such as finish dimensions for example, really require some sort of gauging apparatus to judge them at all.

In order to insure a high standard of quality of their glass packed products certain food manufacturers have employed a system of testing the vacuum after a period of storage. In cooperation with one large food packer the Hartford-Empire Company has made an extensive examination of jars that failed; about one-third were found to have vertical checks across the sealing surface of the jar, permitting leakage under the gasket surface to the interior. It was such a study that led to the development of the new check inspector—equipment which will sort out check afflicted containers before they leave the glass factory.

Considering the requirements demanded of a device which would detect these vertical blemishes on the glass finish—checks—it did not take long for Hartford engineers to conclude that the most efficient tool that could be employed was the photoelectric cell or "electric eye," with its light source, amplifier and relay. In adapting the electronic system to the particular need, the problem was simplified to include only checks at the finish rim and only those in a plane passing through the sealing surface of the jar. The great majority of finish checks, particularly the small ones that are almost imperceptable are of this orientation. It may be mentioned at this point that in this connection and with regard to making the equipment insensitive to vibration resulting from heavy equipment encountered in container plants, General Electric Company engineers contributed their skill to perfecting this phase of the apparatus.

Even with this simplification the problem was not without its difficulties. A seed will scatter as much light as a check will reflect, and unless the seed is large it is not necessary to reject it. Hence, since the primary object of the equipment is to improve the functional

(*Continued on page* 203)

FURNACE OPERATION AND CONTROL

(FURNACE CONTROL)

By ROY S. ARRANDALE
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PART IV

In any continuous process the problem of maintaining control is entirely the problem of maintaining strictly uniform and reproducible operating conditions.

We have found the operating report form of Fig. 12 to be of valuable assistance to process control in providing a daily record of the furnace performance. A spot-check is made every day on the furnace combustion conditions and marked down on the diagrammatic plan view of a furnace shown on the left hand side of the illustration. The latter is useful also for notations with regard to the daily inspection of the condition of the furnace, hot spots, adjustment of cooling "wind," etc.

The remainder of the report is more or less self-explanatory, for glass quality, melting efficiency and feeding and forming efficiency. (NOTE: FDR No. refers to Feeder Number.) In the operation of the furnace we should not lose sight of the forming operation since in the broad picture, the function of furnace control aside from the economics involved, is to provide glass for forming. It goes without saying that the worst bottle in the world can still be made from the best glass.

Likewise, it is possible to run a furnace blindfolded and make good ware provided the furnace load is small enough. But the more intensive the load becomes, the more necessary it becomes to hold the furnace "on the beam" so to speak. In the latter state control instruments become a prerequisite.

The ultimate in any operation, of course, is entirely automatic control, in this case automatic temperature control. However, the barrier confronting such a set-up as applied to anything so large and bulky as a glass furnace has been the lagging response to changes in heat input. Since the instruments involved cannot anticipate what is to follow, the result is repetitive over-shooting of the desired limits. But we can do the next best, which is to take the variability out of the things that make for temperature changes.

The instruments or devices which are undoubtedly the absolute necessities for good furnace control are: 1) Fuel regulation and indication providing constant conditions of quality and amount at the furnace. 2) An optical pyrometer. 3) A portable Orsat. Beyond that, further refinements are as follows in the probable order of importance: 4) Automatic batch feeding. 5) Automatic furnace pressure control. 6) Automatic combustion air control, and 7) Temperature recording.

Oil Firing

Fig. 13 shows in diagrammatic form one arrangement of automatic control equipment which is unique and is functioning effectively in use on Bunker "C" oil. The furnace firing happens to be split up into three different zones, the first two of which cover the melting zone (first three ports of this 5 port furnace): The third covers the "homogenizing zone" (4th and 5th ports). Zone 1 comprises the back wall burner adjacent to the dog house; Zone 2 the outside burner on the back wall which has a higher pressure oil nozzle. Zone 3 the over-the-port burners at No. 4 and No. 5 ports.

The fuel oil system is equipped with a return line back to the tanks, net total fuel into the furnace being registered by the difference between two positive displacement meters, for check against the orifice meter in the main line to the furnace. An air operated differential transmitter on the main oil line to the furnace transposes the orifice differential into a loading air pressure which registers a pressure (rate of

THATCHER MANUFACTURING CO.
Daily Furnace Operating Report

PLANT.....
FURNACE NO. ..... DATE.....

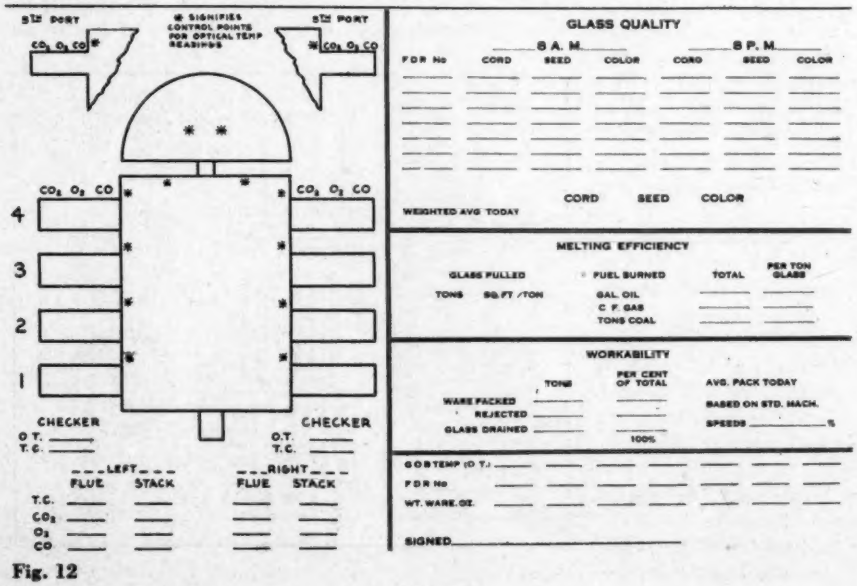


Fig. 12

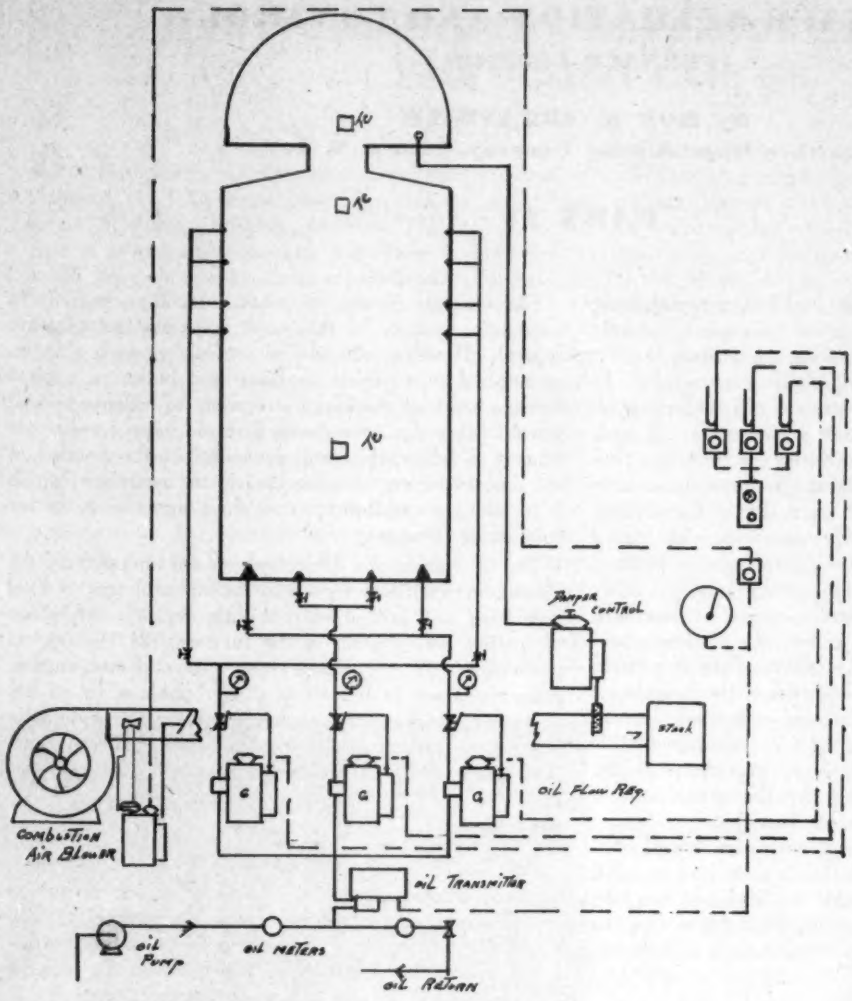


Fig. 13. Thatcher Mfg Co., Furnace No. 2, Olean, N. Y.

flow) on the panel dial in GPM. A chart record is also obtained for rate of flow.

This same loading air pressure is connected through a bleeder control valve at the panel to the diaphragm and lever arm of a secondary combustion air regulator which accordingly holds the rate of flow of combustion air, as metered by an air speed nozzle, in continual balance with the air loading pressure by opening and closing the fan air louvres. The fan takes suction from under the furnace.

The main oil flow then splits off through the separate zone controllers which will each hold a constant oil flow rate in balance with any loading air pressure superimposed upon it, in an infinite number of steps. The three individual bleeder control valves for these three regulators are in series with the main bleeder valve so that the total oil flow can be changed at will without disturbing the proportionate settings. Or conversely, the proportionate settings can be changed at will without disturbing the total.

The panel board arrangement for this set-up is shown in Fig. 14. The oil pressure gauges along the top of the board indicate full line pressure, and zone pressures. The latter will not hold constant of course unless the burner orifices remain clean, in view of the fact that a flow controller will, if any obstruction appears in the line, open up to grasp the same amount of oil and thereby tend to free the burner. This is one feature of the flow control method.

By the same token, when the fuel is shut off for reversal each flow regulator will open wide. Upon reversal, therefore, full line pressure would be thrown onto the burners in the few seconds' time interval required for the controllers to throttle down, were it not for the air transfer valve included on the panel board which bleeds the loading air system to zero during the reversal period. The flow controllers thereby throttle, starting from the closed position instead.

The combustion control valves occupy the central position on the board of Fig. 14, with proportioning between zones, and proportioning of secondary air being shown, for any desired setting, on the mercury manometers directly above. Furnace pressure and three draft points are immediately above that.

The remainder of the instruments comprise the oil-flow indication and recording (right hand side); and electric CO_2 meter and 3 point potentiometer (left hand side). The CO_2 meter, which was included more or less as an

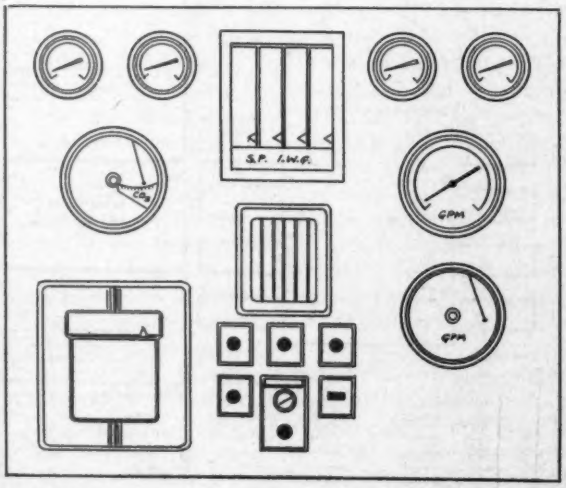


Fig. 14

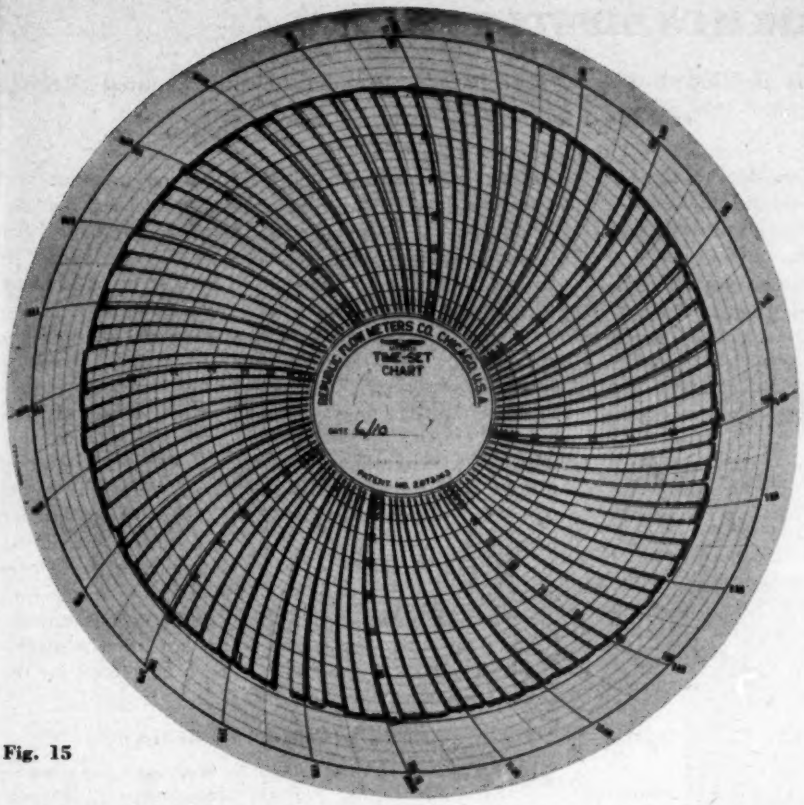


Fig. 15

experiment, involves, as might be expected, more maintenance than the rest of the instruments combined, principally due to the fact that the sample connection in the flue becomes plugged almost daily with a hard deposit of sublimed batch materials. The three temperature points are as measured from thermocouples placed in the furnace crown, one in the refiner, one over the bridge, and one in the melting zone, in the conventional manner.

An oil-flow chart from this operation is shown in Fig. 15. The normal fluctuation will run about 0.05 GPM. The corresponding CO_2 chart for the same period is shown on Fig. 16. Attention is directed to the break that occurs in both charts at 1:15 P.M. The temperature chart of course showed a down-hill record at the same time. The operator, who was not "green," was apparently lulled into forgetfulness and failed to turn the fuel back on after reversal until late in the period. The human element here is one argument for automatic reversals, based either on checker temperature or time, even though it is rarely that such things are repeated. At any rate, the automatic recording of events over the 24-hour operation is of valuable assistance to the foreman.

Generally speaking, flow control is preferable to straight pressure control, although fair pressure regulation is a necessary preliminary to good flow control in any case. But in case straight pressure control, air operated or otherwise, is provided in conjunction with a fuel flow indicator it will be found in time that flow rate will not remain constant for constant pressure because of the fact that the burner system in actual operation does not represent an ideal orifice. The operator will therefore readjust the pressure to suit the flow meter. It is better therefore to control the flow directly.

Natural Gas-Firing

Another such flow control installation is shown in Fig. 17 diagrammatically. In this case there is only one flow regulator controlling total natural gas input to the furnace. Combustion air input is proportioned automatically in the same manner as before. The panel board accommodating this arrange-

(*Continued on page* 190)

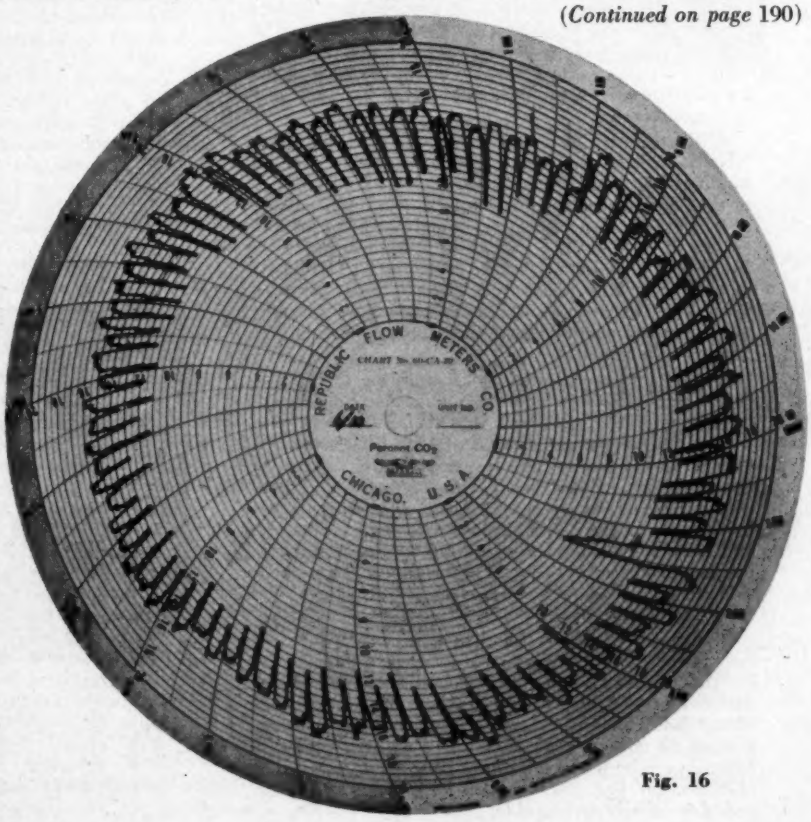


Fig. 16

THE ACS MEETS IN PRINT

A full program of papers is developed despite cancellation of Forty-Seventh Annual Meeting scheduled for Buffalo.

A meeting of the Board of Trustees, the Past Presidents and Committee Chairmen will be held in Buffalo April 16 and 17 for the purpose of transacting urgent and official business which cannot be postponed.

However, cancellation of the annual meeting has not deterred the Society from developing an impressive list of papers for the Glass Division and for the members of the other divisions.

This meeting by mail is designated as the Third War Conference (in print) and the General Session is devoted to Postwar Problems.

Among the papers included in this part of the program is a discussion by F. D. Newbury, Vice President, Westinghouse Electric Manufacturing Company, which presents a statistical analysis of postwar employment. The author argues with the political figures of a sixty million postwar labor force. A brief abstract of the paper outlining Mr. Newbury's reasoning and conclusion follows:

Postwar Employment

By F. D. Newbury: Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.

This paper will discuss only one phase of this broad question, namely, the size of the postwar-labor force and the number of civilian jobs that corresponds to a satisfactory level of the civilian employment. Unfortunately, this difficult statistical problem has become a political issue. President Roosevelt has promised 60 million "jobs," and this figure has been quite generally adopted by those who appear to be interested in inflating the size of the problem beyond the ability of private industry.

All of the high estimates of the size of the postwar-labor force start with the U. S. Census figures of 1940, which showed a labor force of nearly 53 million. If to this figure is added the normal annual net increase of 650,000 workers, there results a labor force of 57.3 million in 1947 or 59.3 million in 1950. The political figure of "60 million jobs" is probably a "free-hand" extension of these figures. A labor force as large as 60 million workers could not be recruited from the total population without robbing the schools and the homes of the nation.

A safer and more satisfactory approach to this statistical problem is to ignore the abnormal employment conditions of the war years, and to fall back on total population figures and the percentages of the several classes of men and women who normally appear in the peacetime-labor force. This method takes into account the trends toward boys and girls entering the labor force at older ages, because of longer schooling, and older men and women leaving the labor force at earlier ages because of social security and private pension plans. This method leads to an estimate of the 1950 labor force of not over 56 million.

Civilian employment (number of necessary jobs) is estimated by subtracting two million for military service and two million for the irreducible unemployment that exists even in prosperous times. This results in 52 million jobs. The difference between the political goal of 60 million jobs and a more realistic figure of 52 million jobs is the difference between an attainable objective and one that would be very difficult to reach and also socially undesirable.

Other papers on the General Session program are: "Postwar Construction Project Plans, a Progress Report," by Thomas S. Holden, F. W. Dodge Corporation; "The Ceramic Industry and the Returned Service Man," by Captain Arthur J. Blume, 1587th Service Command Unit, Armed Forces Induction Station, Huntington, W. Va., and "War Veterans in the Postwar Ceramic Industry," by J. E. Eagle, Chief, Non-Metals Section, Miscellaneous Minerals Division, War Production Board.

While the Glass Division Program lists a total of fourteen papers developed by Louis Navias, Program Committee Chairman, the elimination of an actual meeting place, of course, precludes the possibility of the round table discussions and open forums which have become familiar activities of the Glass Division members during the Annual Meetings. It is apparent, too, that the program does not include the "practical" type of paper to the extent which has been customary at recent meetings. Nevereless, among the papers which are listed, abstracts of which follow, there should be much of interest for the Glass Division membership.

GLASS DIVISION PROGRAM

1. Defects in Glass Caused by Working Conditions

By W. F. Curtis: Fostoria Glass Company, Moundsville, W. Va.

The purpose of this paper is to form a background for a discussion on the problem of defective glass due to working conditions as found in hand plants. Some of the more common defects, such as cords, blisters, seeds, laps, wave, chill marks, crizzels, and smears, are listed and their causes discussed. The temperature of the glass, correct gathering punty or pipe, the use of proper marver plate or bit plate, the temperature of the molds, and improper handling tools are some of the problems that enter into the discussion. There is also the problem of the inept, untrained, and unskilled workman whch is acute at the present time under the critical manpower shortage.

2. Constitution of Extra Dense Flint Glasses

By K. Fajans: Department of Chemistry, University of Michigan, Ann Arbor, Mich, and Glass Science; and N. J. Kreidl: Bausch & Lomb Optical Company, Rochester, N. Y.

The formation of glass is favored by such properties of ions and molecules which are hindering the transition from their arangement in the viscous liquid state to the thermo-dynamically more stable crystalline state. In the case of network-forming oxygen ions, the favorable property is their strong binding and considerable deviation from spherical symmetry due to the two-sided strongly polarizing action of the neighboring cations B^{3+}, Si^{4+}, P^{5+}.

The interlinkage of SiO_4, PO_4, BO_4, or BO_3, groups hitherto was believed to be a prerequisite of glass formation unless some other ion capable of substituting for silicon could partially take its place in similar groups. The stability of silicate, borate, phosphate glasses with very high lead content has been little understood because the large Pb^{++} ion could not be supposed to replace the small B^{3+}, Si^{4+}, P^{5+} as a network former. For the same reason, and being only doubly charged, it cannot be assumed to strongly polarize the O^{2-} ions.

(*Continued on page* 189)

A REPORT ON GLASS FRACTURES

By ROGER F. SCOTT
Armstrong Cork Co., Millville, N. J.

The three flat circular laminated glass plates were each made from two pieces of glass about 1/16 inch thick cemented together with a plastic bond or similar material so that the whole is about ⅛ inch in thickness.

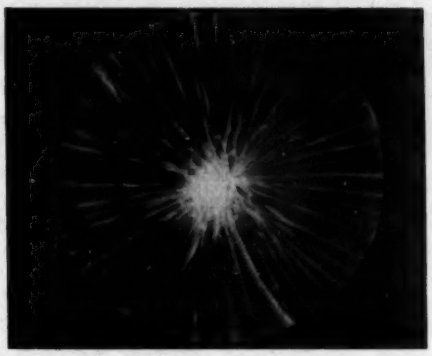


Fig. 1.

The disk shown in Figure 1 is about 2⅝ inches in diameter. It was broken by an impact near the center. The upper or impacted glass had a cone of percussion formed at the point of impact with 57 fractures radiating from the cone. The fractures in the lower glass originated with what Dr. F. W. Preston would call a flexure fracture in which the lower surface away from the impact is simply stretched beyond its tensile limit. The focal point for this system of fractures is a short straight break with 56 fractures radiating from it. It is interesting to note that the focal point of the system of fractures in the lower glass is not directly opposite the cone of impact in the upper glass. The photograph shows the focal point in the lower glass slightly higher than for the upper glass. However, all but twelve of the radial fractures in the upper piece of glass occurred almost exactly opposite a similar fracture in the lower glass, almost as if the two fractures were one.

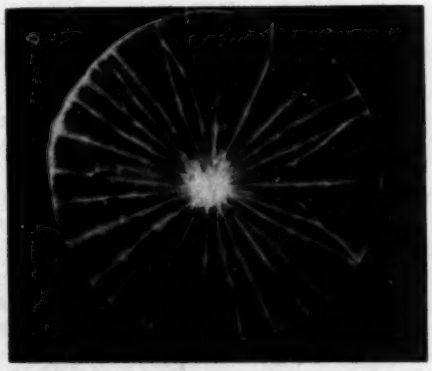


Fig. 2.

The disk shown in Figure 2 is also about 2⅝ inches in diameter. As in the disk in Figure 1, the disk had been broken from an impact near the center which formed a cone in the upper or impacted glass with 30 radial fractures extending from it. Each of these radial fractures formed extremely rough surfaces causing these fractures to have the appearance of wet feathers. The glass on the lower side of the plastic broke with the flexure type of origin with smooth radial fractures corresponding to each radial fracture in the upper glass. In addition to these fractures, there was a discontinuous spiral fracture formed in the upper or impacted glass only. This fracture unlike the radial fractures in the same glass, formed relatively smooth fracture surfaces.

The third disk shown in Figure 3, is somewhat smaller, being two inches in diameter. The impacted glass shows the percussion cone formed at the point of impact with 33 smooth fractures radiating from this cone. The lower disk has 35 fractures radiating from the flexure origin,

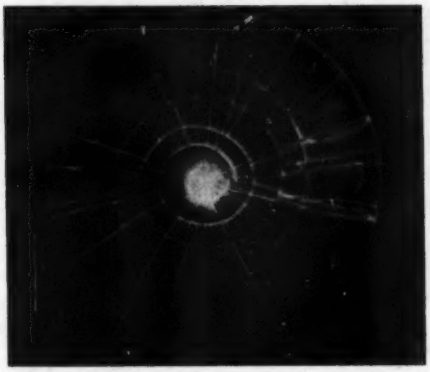


Fig. 3.

all but eight of which occur directly beneath a corresponding fracture in the upper disk. In addition, there is a very uniform continuous spiral fracture in the impacted glass which starts near the impact cone and makes nearly three and a half revolutions.

There are three distinct types of fractures represented in these disks; two of them, the impact cone and the radial fractures, occur in all three disks, the third, the spiral fracture, occurs in two of the disks.

The first two fractures are well known and have been described many times. The cone fractures are caused by the high but localized tension stress surrounding the impacted point caused by the indentation of the glass at that point. The radial flexure breaks are caused by the bending of the glass sheet so that the surface opposite the impact is thrown into tension. In this latter type, the fracture travels faster on the lower surface opposite the impact.

R. N. Hayward (*Jour. Soc. Glass Tech., Trans.* 1944, 28, p. 133), has shown that laminated glass bends more readily than ordinary sheet glass. This is true because the soft interlayer allows the laminated glass to bend more nearly as if it were two pieces of glass, with the interlayer showing some resistance to distortion. Since the deflection of a disk is inversely proportional to the cube of the thickness, it can be seen that the deflection

(*Continued on page* 196)

GLASS RESEARCH INSTITUTE FOUNDED IN INDIA

A Central Glass and Silicate Research Institute will be established in Calcutta, India, on the basis of recommendations accepted by the competent authorities on August 1, 1944. The chief functions of the institute will be the experimental investigation of problems in the field of glass technology, the testing and standardization of materials and glassware, the collection and distribution of technological information and the education of glass technologists. The initial appropriation comprises a nonrecurring expenditure of $400,000 and a recurring expenditure of $50,000 a year. Half of the latter amount is designated to the employment of about twelve research workers, six office workers, six mechanics, one librarian, one maintenance officer and eighteen unskilled helpers. The equipment corresponds to that of a complete up-to-date research laboratory of a large American company. In three to four years the institute is expected to expand to about twice its size with a staff of about thirty research men.

It is realized in India that a sound development of the institute will depend upon skillful relations with glass technologists outside its own organization. Facilities and funds are provided for sending glass technologists abroad and inviting foreign specialists to work in the institute. America is in the foreground of this concept and American assistance is believed essential for the near future of the institution. The growing independence of science and industry in Canada and Australia with the support of Britain and the United States has found considerable attention in India.

The American Ceramic Society is prominently listed as an illustration of successful collaboration of science and industry. The economical situation of the Indian glass industry, however, is entirely different from that in America. During its rather recent growth from scarce beginnings, it did not enjoy protection in the form of protective tariff policy and the brief respite during World War I was followed by an ever increasing pressure of imported goods. This recalls the anxiety with which much stronger industries watched the importation of Japanese glassware based upon the desire of Japan to acquire foreign currency. In 1939 about 55 per cent of the bangles, 60 per cent of the bottles and 70 per cent of the tableware imported to India were of Japanese origin and the total amount of imported glassware approximated the home production.

The "Indian Goods" movement of the early thirties suggested forcefully the enactment of protective tariffs. The attitude of the Indian Tariff Board in this situation proved to be of paramount importance for the organization of an Indian Glass Institute. The board whose president is Dr. Matthai felt, correctly, that the introduction of protective tariffs presupposes the immediate undertaking of progressive research and industrial readjustment, otherwise the burden imposed on the consumers by far outweigh the advantages gained by industry. As a matter of fact, the Indian Glass Institute was planned and finally was established as an outcome of this recommendation.

The prewar value of the glass manufactured by India's 150 factories was approximately five million dollars. Even though this figure is not large compared to the potentialities of the country, the Research Institute appears justified in spending $50,000 or 1 per cent of the total production value. An expenditure of this order would be easily carried and eventually earned by industry without public assistance.

A closer collaboration of the Indian glass industry now organized locally and commercially, perhaps on the basis of the nucleus of the Indian Ceramic Society, is expected as a consequence of the foundation of the institute. The basic factors necessary for a thriving glass industry, such as raw materials, fuel, labor and location, were optimistically analyzed in a recent study of Mr. Atma Ram. The expansion of a domestic chemical industry has now overcome the last bottleneck, the necessity of soda importation. The addition to the sound basic conditions of glass manufacture of progressive research promises a definite advancement of the glass industry in India, a country the industrial growth of which may well surprise this century.

LARGE OPTICAL CRYSTALS GROWN AT MICA SURFACES

When molten sodium nitrate is poured into an aluminum dish and mica floated on its surface, the cooling melt begins to solidify at the surface of the mica and in as little as twenty minutes perfectly developed sizeable crystals are obtained. The manufacture of large synthetic crystals is important in military optics, since the application of natural calcite is restricted by the rarity of large pieces of well grown natural calcite. The use of sodium nitrate for the synthesis of large crystals of the calcite type has been known, but the growth of such large crystals could not be controlled sufficiently to obtain a regular material for optical use.

Dr. Cutler D. West, of the Polaroid Corporation, discovered the ingenuous method of controlling the growth of sodium nitrate crystals by starting it at a mica surface. The discovery is based on the identity of the spacing of certain atomic interstices on the mica surface with the desired spacing of the sodium ions in the sodium nitrate lattice. The interstices originate, probably, through leaching of potassium from the mica surface into the sodium nitrate melt. Once the sodium ions are aligned in a perfect pattern on this "peg and hole" surface of leached mica, the first layer of crystalline sodium nitrate grows as regularly as the mica lattice. The orientation of subsequent layers on the hardened first atomic layer will automatically follow this perfect pattern.

Crystals of calcite properties have been grown by this process in areas 7½" x 15" x ¾", and possess high shock resistance. There are no limitations to the area of growth other than the size of perfect sheets of mica obtainable, that is about three feet in diameter.

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During February

Furnaces

The Brown Instrument Co., through patentees Howard O. McGillin and Jos. P. Vollrath of Philadelphia has received patent 2,368,937 for a temperature control system for the forehearth of furnaces which supply gobs of glass to forming machines. In such furnaces with the glass passing through a channel from the melting and refining zones to the forehearth, burners are located at intervals along the channel and in the forehearth. These are used to bring the glass to the proper condition of working for the particular ware to be formed. Generally the burners in the channel are manually adjusted to supply a fairly large portion of the total heat needed, while the burners in the forehearth are automatically adjusted to supply the remainder. At times the channel burners may supply more than enough or not enough heat so that the control system automatically shuts off or opens wide the forehearth burners. When this occurs there is in effect no control of the glass temperature since only one set of burners is going and that at a fixed rate. In order to overcome this condition the inventors provide a signal means connected to the forehearth burner control which flashes lights to indicate to the operator that the control is approaching one or the other of its limits. Such an indication shows that the channel burners are supplying more or less than their proportion of the heat and should be adjusted manually in a direction that these burners will supply more nearly their proper percentage of the total heat. In this way it is insured that the forehearth burners will always be on and that they will be supplying a controllable percentage of the total heat.

In addition to details of the control system, the patent particularly stresses the construction of the thermocouple protective system which allows a couple to be maintained under the surface of the glass near the feeder in the forehearth. The protection tube is platinum and is inserted through the wall. The couple may either be of noble metal or base metal.

Miscellaneous Processes

Fig. 1 from patent 2,369,764 assigned to Bausch & Lomb Optical Co. shows the apparatus in which Osmar A. Ullrich, Jr., applies a volatilized coating to glass pieces intended as optical wedges for use in any optical instrument in which it is desired to vary the intensity of the transmitted light rays. This is an evacuated chamber. The volatilized coating material is deposited on the glass elements 18 but is partially masked from them by cylinder 26 which rotates. Because of its irregular length the cylinder uncovers the lower part of the glass elements for a longer time than the upper part, and results in the deposition of a film having graduated thickness from one end to the other.

Other optical glass patents were 2,369,114 to Jorgen C. Andersen of Rochester, N. Y., for a lens edge grinding machine, and 2,367,704 to Victor Walker of Fort Erie, Ontario, for a method of preparing optical test

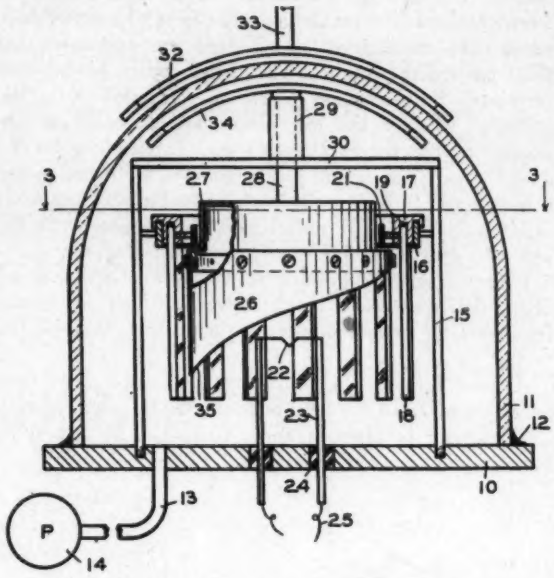


Fig. 1. Ullrich, 2,369,764 : Hood for coating optical wedges in which the shape of a rotating cylinder 26 is such as to partially shield the glass units 18 so that the thickness of coating will vary from one end to the other.

pieces. Walker relates the optical glass practice of selecting chunks of fused glass and remelting these selected stock fragments in a clay mold. Upon removal from the mold, enough foreign matter adheres to make inspection of the interior difficult or impossible without grinding and polishing two opposite faces. To introduce a labor saving step he removes the rough skin surface by treatment with acid compositions. These are so chosen as to accomplish the aim without producing an opaque etched surface. In some cases he may use a mixture of sulphuric and hydrofluoric acids in the five to one ratio. In other cases as with barium silicate compositions the mixture may consist of five parts phosphoric and one part hydrofluoric acids.

In American Optical Co. patent 2,369,189, Edgar D. Tillyer and James W. Ford describe a method of testing for completeness of annealing of optical glass batch samples. They state that the absence of strain as evidenced by polarized light is not a wholly satisfactory criterion of completeness of annealing. Their method is based upon the fact that when any particular glass composition is completely compacted it has also reached its maximum index of refraction. They carefully select several pieces of the desired composition and anneal them to the point of maximum index of refraction, thereafter using these samples for comparison with other glass pieces of the same composition which are to be judged. These pieces to be used as samples are first annealed by some carefully chosen schedule. The glass is then removed from the furnace and its index of refraction determined. It is put back into the furnace and held at a somewhat lower temperature for a week or

two, and its index again measured. If the index has risen, as is likely if the original annealing schedule was not correctly chosen, the glass is returned to the furnace for another week or two at about 50 F lower temperature. This procedure is continued until the index no longer rises and the maximum index of refraction has been obtained. The maximum index is recorded and these pieces are maintained as standard test specimens for this particular composition. After once having determined the maximum index of refraction it is immaterial whether the test pieces are annealed or unannealed when they are put to use. In carrying out the annealing of subsequent batch samples these test pieces are scattered throughout the setting and a heat treatment is chosen which will reduce the test specimens to the recorded maximum figure for index of refraction.

Patent 2,369,557 granted to Frederick Gettleman of Milwaukee concerns a bottle conveyor which has means for rejecting broken pieces of glass which may be fed to it.

A hood for spraying lubricants on bottles after they have passed from the lehr is described in patent 2,369,737 assigned to Owens-Illinois Glass Co. by Albert S. Jackson and Ernest W. Summers.

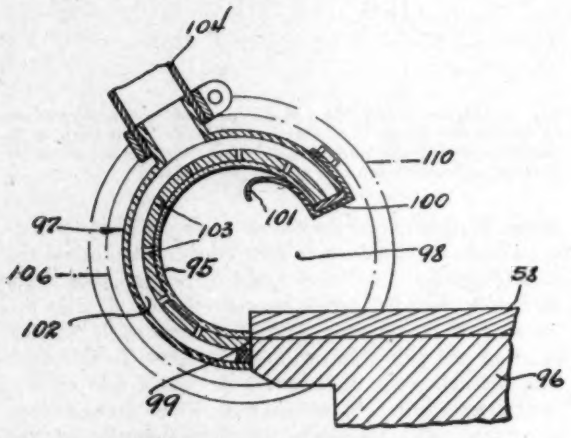


Fig. 2. Owen, 2,370,575 : Mold for shaping glass plates into partial cylinders.

Sheet and Plate Glass

Fig. 2 is from patent 2,370,575 issued to Wm. Owen of Pittsburgh, Pa. (Pittsburgh Plate Glass Co.), and shows one element of a machine for bending glass sheets to approximately cylindrical form. A pusher 58 forces the heated and softened sheet slowly into the mold which is in the form of approximately a three-quarter cylinder. The interior of the mold is shaped to the curvature to which it is desired to bend the glass. It has an internal chamber with openings 103 communicating through the mold walls to allow the application of vacuum to aid in drawing the sheet to the molding surface.

Another patent concerned with the bending of sheets is 2,369,368 assigned to Libbey-Owens-Ford Glass Co. by Ormond H. Paddock and John L. Drake, which describes apparatus for both tempering and bending. The bending means is associated with a discharge elevator which removes the sheets from the tempering furnace. Other Libbey-Owens-Ford patents are 2,369,350 to Chas. D. Haven for a process of metalizing glass, and 2,369,382 to George B. Watkins for a multiple glazing unit. In uniting metal to glass by a soldering process Haven had previously reported in patent 2,293,822 that it was first necessary to apply a metallic coating to the glass surface by a metal spray gun. He had used an alloy consisting of copper with an addition of 0.5 to 4.5 per cent titanium. Now he has found that a still better alloy for this purpose results if some chromium is also added, for example about half a per cent.

Chas. Trevail and Kurt P. Gladney of London, Ontario, received patent 2,367,903 for a spray method of silvering mirrors which is intended as an improvement on the process disclosed in patent 2,214,476 issued in 1940. At that time it was shown that the process could be carried out by means of an air jet to which separately formed silvering and reducing solutions were fed, there to be intimately mixed and sprayed onto the glass surface. The solutions previously disclosed were less satisfactory than those now revealed. Their latest silvering solution is formed by dissolving 4 ounces of silver nitrate and 8 to 12 ounces of aqueous ammonia in 160 ounces of distilled water. The reducing solution is formed by dissolving 2 ounces of hydrazine sulphate and 0.5 ounce of crystalline magnesium sulphate in 160 ounces of water. As compared with the prior patented process this is a richer silvering solution and the magnesium sulphate represents a new ingredient. This patent is assigned to Hobbs Glass, Ltd.

In the latest of the Bausch & Lomb patents on reflection reducing films (2,369,741) Frank L. Jones and Theodore J. Zak of Rochester, N. Y., give quite a lot of technical detail on surface leaching processes. The procedures covered by their patent involve a heat treatment of the ware to stabilize the high silica film after the alkalies or other ingredients have in part been removed by leaching.

A plate glass cutting board is covered by patent 2,370,470 which was granted to Joseph Joss of Douglas, Ariz.

In describing so fully the furnace, carrier system bending apparatus, air blast, conveyors, elevators and other units which go to make up a plate glass tempering system, Arthur H. Vaughan's patent 2,370,381 (The Electric Furnace Co.) is a document which cannot be abstracted in the space available here. The patent specification is devoted to a full discussion of the exacting requirements of these processes and he has been allowed 33 claims directed to various aspects of them.

Glass Wool and Fiber

Patents concerned with glass fibers included 2,369,481 to Piero Modigliani of Leghorn, Italy (Owens-Corning Fiberglas Corp.), for the manufacture of spun material having a structure very similar to that of spun tubular hose, and which may envelop a wire or metallic tube, and patent 2,369,876 to Richard F. Warren, Jr., of Stratford, Conn., for a fiber rope. The latter product is made of bundles of spirally arranged fibers in combination with metallic wires. A third patent 2,369,605 concerns the old problem of removing pellets or shot from mineral wool in the blowing room. The inventor, E. R. Powell of Johns-Manville Corp., blows the fibers against a cylinder having an horizontal axis, this collecting the shot while the fibers are deflected above it and are then allowed to collect on a conveyor.

GJ Research Digest

Practical Interpretations of Glass Technology

Relaxation of Stresses in Annealing Glass

Because of their high viscosity, glasses and certain so-called plastics are easily undercooled and superheated. As a result, their properties including viscosity, are usually changing continually while these materials are at temperatures within their annealing ranges, even if the temperature is constant. That is, the changes continue until the materials reach equilibrium conditions at the temperature at which the annealing takes place. This change in viscosity which accompanies the approach to equilibrium greatly affects the rate at which stresses relax when strained glass is being annealed at a constant temperature.

As the annealing process for the relaxation of stresses is a very important matter in the production of glass, it has been the subject of many intensive studies, and various attempts have been made to relate the relaxation of the stresses to the time and temperature of annealing. The exponential relation derived from Maxwell's equation for viscous flow, without considering the change in viscosity at a constant annealing temperature, is usually entirely inadequate. Also, the substitute reciprocal relation proposed by Adams and Williamson is generally unsatisfactory.

In R. P. 1637 which appears in February, 1945, issue of the *Bureau of Standards, Journal of Research*, Arthur Q. Tool has derived another relation. It is based on Maxwell's equation but takes into account the change in viscosity. To compare its application with that of the relation proposed by Adams and Williamson, it has been applied to their data on the relaxation of stresses at various temperatures and in several kinds of glass. This comparison greatly favors the new relation. Fortunately, it also leads to a clearer understanding of the behavior and nature of glass.

Effect of Fluorine and Phosphorus Pentoxide on Properties of Soda-Dolomite Lime-Silica Glass

During the latter part of 1941, supplies of dense soda ash became short. This situation led to an investigation by many glass manufacturers of glass compositions and materials that could replace the prevailing formulations and extend to the limit the available supply of soda ash. Work done along these lines by the General Research Laboratories of the Owens-Illinois Glass Co. was recently reported in the December, 1944, issue of *The Journal of The American Ceramic Society*.

As the use of lithia or borax were ruled out by economic considerations, only fluorides remained as materials that might have good possibilities. In addition, since the fluoride-bearing slags from phosphate operations contain in addition to the fluorine; alumina, silica, lime, alkali and a significant quantity of phosphorus pentoxide, an investigation was also made of this latter constituent.

From the data obtained, it was concluded that: 1—Fluorine is very effective in reducing the viscosity of a glass and it is quite probable that it will increase the working range. 2—Fluorine will rapidly increase the liquidus temperature in the base glasses investigated. The quantity used to replace soda must therefore be limited. 3—Fluorine in the range used in these experiments does not decrease the chemical resistance. 4—Fluorine compounds are probably vaporized above the annealing temperature of the glass. 5—Phosphorus pentoxide has but little effect on the viscosity characteristics of the base glass used in this work when it replaces silica. 6—Phosphorus pentoxide does not affect the resistance properties in the range investigated when it replaces either CaO·MgO or SiO_2. 7—The tendency of glasses to become opalescent in the working range when phosphorus pentoxide is present suggests that the element is not desirable in soda-lime glasses.

The Spectrochemical Determination of Iron in Glass Sands

In the July, 1944, issue of the *Journal of the South African Chemical Institute*, L. H. Ahrens reports on the results of an investigation dealing with the determination of iron in glass sands by spectrochemical methods. Such methods not only allow an increase in the rate of iron determinations but also the spectra produced by each sand would provide a permanent record of other impurities present.

The method which is described uses silicon as an internal standard. Although the employment of an internal standard for the analysis of powders is sometimes regarded as offering no advantages, in this particular case silicon behaves very efficiently as an internal standard, with the result that a very satisfactory accuracy was obtained, the probable error being 4.9 per cent of the total iron content.

Interference by potassium was investigated and this element was found to produce high results when present in quantity. (Up to as much as 0.25 per cent produces no appreciable effects on the live intensity ratios.) With the assistance of graphs, this effect is shown to be attributable to the pronounced depressant effect that potassium has on the spectrum of silicon.

The experimental glasses were prepared from Ottawa sand, burned dolomite lime, Solvay soda ash, technical sodium phosphate and sodium fluoride. About four and a half pounds of each glass in the series was melted in a large covered platinum crucible in a gas-fired furnace. The glasses were stirred several times during the initial melting period and were poured, crushed, and remelted with additional stirring. The total time of melting and remelting was approximately twenty hours at 2600°F.

(*Continued on page* 204)

CURRENT STATISTICAL POSITION OF GLASS

This month the usual style and layout of the Current Statistical Position of Glass must necessarily undergo decided changes. War conditions have finally interposed insurmountable difficulties precluding reliable conversion to dollar values of some of the production data heretofore used for the purpose. It is hoped that the familiar bar chart, together with its detailed editorial comment relating to the dollar values of plate, window, containers and all other types of glassware can be resumed in the not too distant future.

However, despite the difficulties encountered in converting the statistical data by types of ware to dollar values for the Production Index, THE GLASS INDUSTRY is able to continue uninterruptedly the chart and analysis giving the over-all industry picture of monthly trends as it pertains to production, employment and payrolls.

Concerning the detailed breakdown of glass containers by classes of ware, as announced last month the current statistics (month of January) were unavailable. However, in this review we include the January and February data showing prduction and shipment figures for the various classes of container ware.

Also omitted from the last issue were the figures on production of automatic tumbler ware and sales of machine-made table, kitchen and household glassware. While the problems pertaining to the expansion of this data have not been, up to the present time resolved so that normally current figures (February) can be published, statistics for the month of January, together with corralary data appears in these columns.

Automatic tumbler production for January totalled 3,443,723 dozens, representing a decrease of about 25 per cent from the preceeding month of December and also a decrease of 30.5 per cent in comparison with the corresponding month of January a year ago. Shipments of automatic tumblers for January totalled 4,127,369 dozens as compared to 4,605,558 dozens for December

GLASS CONTAINERS

SHIPMENTS, PRODUCTION AND STOCKS OF GLASS CONTAINERS BY TYPE

Type of container	JANUARY 1945 (All figures are in gross)			FEBRUARY 1945 (All figures are in gross)		
	Shipments during month	Production during month	Finished stocks on hand at end of month	Shipments during month	Production during month	Finished stocks on hand at end of month
NARROW NECK						
Food	520,619	—	—	571,503	—	—
Medicinal and Health Supplies	1,007,650	—	—	894,011	—	—
Chemical, Household and Industrial	505,921	—	—	451,805	—	—
Toiletries and Cosmetics	422,870	—	—	402,686	—	—
Total (Items 1 through 4)	2,457,060	2,591,890	2,184,950	2,320,005	2,297,825	2,184,950
Beverage, Returnable	568,629	581,279	394,080	502,499	462,849	339,432
Beverage, Non-Returnable	—	—	—	—	—	—
Beer, Returnable	533,369	536,426	73,533	513,433	588,855	100,716
Beer, Non-Returnable	498,952	509,948	53,956	390,433	412,324	63,066
Liquor	656,428	702,094	333,170	644,507	43,385	314,119
Wine	207,070	209,250	120,206	178,424	192,827	130,259
Total Narrow Neck	4,921,508	5,130,887	3,159,895	4,549,301	4,498,064	3,098,009
WIDE MOUTH						
Food	2,253,482	—	—	1,959,933	—	—
Medicinal and Health Supplies	252,240	—	—	219,956	—	—
Chemical, Household and Industrial	86,882	—	—	69,517	—	—
Toiletries and Cosmetics	111,680	—	—	136,318	—	—
Total (Items 13 through 16)	2,704,284	2,510,577	1,381,551	2,385,724	2,405,380	1,457,621
Packers' Tumblers	87,922	68,392	19,899	81,407	72,931	19,753
Dairy Products	268,418	282,844	311,997	265,347	250,122	290,768
Fruit Jars	57,818	38,223	475,316	74,797	64,165	476,854
Jelly Glasses	5,068	—	11,880	9,846	13,819	15,566
Total Wide Mouth	3,123,510	2,900,036	2,200,643	2,817,121	2,806,407	2,260,562
Total Domestic	8,045,018	8,050,923	5,360,538	7,366,422	7,495,253	5,358,571
Export Shipments	221,934	—	—	128,831	—	—
Grand Total	8,266,952	8,030,923	5,360,538	7,495,253	7,495,253	5,358,571

and a decrease of 15.8 per cent from January 1944. Finished stocks on hand as of the end of January were 4,764,865 dozens as compared to 4,967,782 dozens for January 1944—a decrease in inventory of 4.1 per cent.

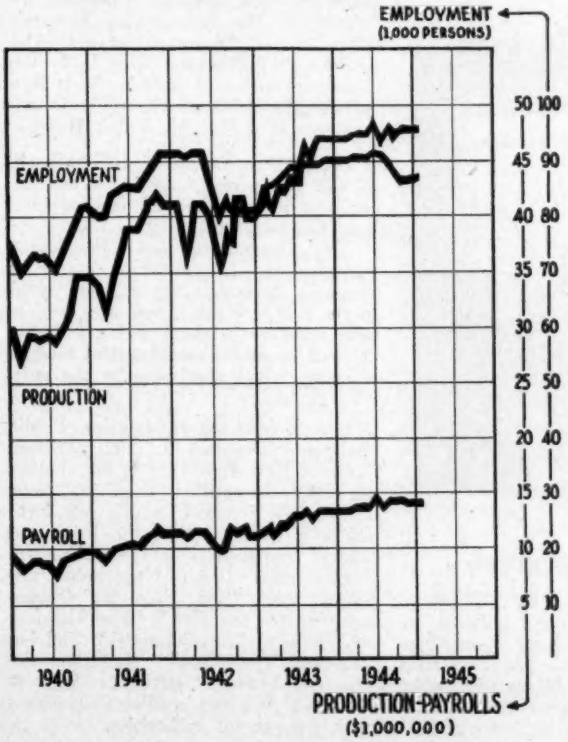
Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for January were reported at 2,705,002 dozens, a slight decrease from the 2,900,860 dozens shipped in the preceeding month, but a decided increase of 77.4 per cent over the correponding month of January, 1944. Shipments for the twelve month period ending January, 1945, amounted to 30,568,584 dozens, a decrease of 8.6 per cent compared to the corresponding period of the year before.

Plate glass production for February, 1945, totalled 7,363,152 sq. ft., as reported by the Hughes Statistical Bureau. This is a decrease of 16 per cent from January and a very slight decrease from production during February, 1944.

Employment and payrolls: The total number of persons employed in the glass industry during January were 88,000. This compares with 87,800 employed in December, and with 91,000 employed during January, 1944. Payrolls for January were estimated at $14,500,000, the same as reported for December.

GI THE GLASS INDUSTRY'S INDEX

Monthly Trends Through January, 1945



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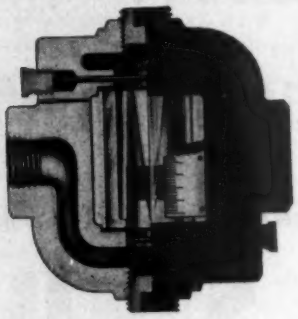
NEW EQUIPMENT AND SUPPLIES

NEW TYPE FLOW INDICATOR



Fischer & Porter Company, Hatboro, Pennsylvania, has released information on their new Rotasight Flow Rate Indicator. This little instrument indicates the true flow rate, even though it is very compact and comparatively inexpensive.

The Rotasight operates on the rotameter area-type principle and has a V-ported transparent metering tube with a float which rises in direct proportion to the flow through the meter.

One of the most interesting applications described is the use of the Rotasight as a flow rate alarm. The manufacturer claims that it is the only alarm that is operated by flow rate changes only and which is equally sensitive at all points in its flow range because of its straight line calibrations.

There is a Bulletin 92-C which describes this instrument.

RECO CONTROL TIMER

The new RECO Control Timer, produced by the Reynolds Electric Company, Chicago, Illinois, was designed for controlling manufacturing operations in which starting is initiated by momentary contact push button, stopping automaically at pre-set time.

The RECO can also be equipped with interlocking controls so that each operation must be completed in correct sequence before the next is started. Failure at any point would post a signal and timer would re-cycle automatically to starting position.

One of the many possible applications of the RECO Timer is as an hydraulic press control in which pressure valves are shut off upon reaching a certain tonnage, holding the pressure for predetermined time and signaling the operator.

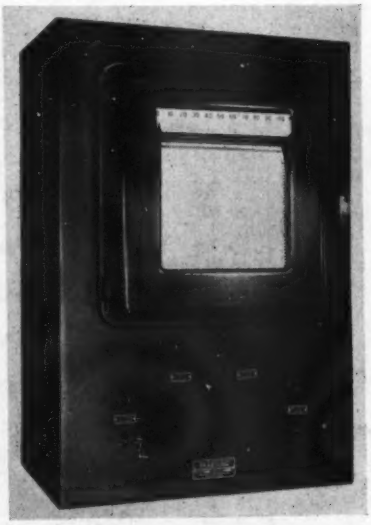
It is equipped with Silver Contacts and has a two circuit control. It has synchronous motor for operating on 115 V., 60 cycle A.C. current. However, when desired it can be equipped with additional circuits and arranged for other current specifications.

TELEVAC RECORDING INSTRUMENTS

A new group of recording instruments designated TELEVAC has just been announced by Precision Scientific Co., of Chicago, Illinois.

The type "MR" instrument with a range of 0-500 microns utilizes the new Televac ℱ500 Thermal Gauge with specially treated elements. Features of latter include coated filaments to prevent "off calibration" periods due to water, oil vapor or other contaminating vapors, increased sensitivity gained through use of two filaments in both standard and variable tubes of the vacuum gauge, all gauges are interchangeable without recalibration, and the user is assured of duplicate readings in terms of absolute pressure in microns. The gauge is supplied with a special Leeds and Northrup Micromax Strip Chart Recorder calibrated directly in microns.

The type "S" recorder (illustrated) for ultra vacuum contains two ranges—0-500 microns for pressures above 1 micron, and utilizing the ℱ500 thermal gauge in this range and an industrial type ionization gauge for the range 0 to 0.4 microns. Accurate readings may be obtained down to 10^{-6} mm. Hg. (.001 micron). The type "S" instrument also features a safety circuit which makes it impossible to turn on the ionization gauge until a vacuum of 1 micron has been reached. Average life of ionization gauge is 3,000 hours.



CATALOGUES RECEIVED

Glyco Products Co., Inc., Brooklyn, N. Y., has a 16 page bulletin entitled, "A High Melting Point Synthetic Wax." This gives detailed information on the high melting point synthetic wax produced by the company under the name of Acrawax C.

The properties of the wax are listed and indexed in the bulletin, and a great many of its specific applications are mentioned in detail.

Graton & Knight Company, Worcester, Mass., is destributing its new Leather Belting Selection and Application Manual. This 56-page manual offers data, charts and specifications to support the following headings—how to pick the right leather belt for the job, including information on tannages; the figuring of belt dimensions, etc.; how to decide between Modern Group Drive and Automatic Tension (pivoted motor base) Drive, etc.

The B. F. Goodrich Company, Akron, Ohio, has just published a new catalogue section on its all-synthetic industrial rubber gloves. One feature is a page devoted to illustrated instructions on how to get the most service at the lowest cost from acid and industrial rubber gloves. A page also is devoted to the company's line of plastic treated industrial aprons.

The Chain Belt Company, Milwaukee, Wis., announces a new bulletin No. 462 descriptive of Rex apron and pan feeders and conveyors. Rex apron and pan conveyors are used for handling coal, coke, ore, cement, rock, chemicals, bulk parts and many other materials. The bulletin contains design details, cross sections, capacity tables and specifications tabulated for quick comparison.

Multiple V-Belt Drive Association, Chicago, Ill., has prepared, under the direction of the Engineering Research Committee of the association, a booklet entitled "19 Reasons Why It Is the Dominant Drive of Industry." It is a primer-like presentation of basic advantages of a Multiple V-Belt Drive.

Fish-Schurman Corporation, New York, N. Y., has a new bulletin OC 305 describing its improved FS Optical Contour Comparator.

This Comparator is of all welded construction. In addition to its use as a means for comparing intricate metal parts, it is now being used as a projection machine in the printing industry as well as in the metallurgical field to examine metal specimens by the strip film method.

Research Institute of America, Public Relations Department, 292 Madison Avenue, New York City, is distributing an Analysis entitled "Rehiring Your Company's Veterans" which sets forth the employers' side of the legal and ethical responsibilities toward returning veterans. Some of the points discussed are: "Your Rehiring Obligations Under the Law," "The Meaning of 'Changed Circumstances'," "Solving Seniority Questions," "Handling the Disabled Veteran," etc. The Analysis has been prepared in close cooperation with government authorities.

(*Continued from page* 180)

A theoretical study of the Polarization of cations by anions leads to a new picture of the constitution of extra dense flint glasses. The six S^2 electrons of Pb^{++} are easily polarizable and can be expected to be repelled and loosened in the glass by the surrounding anions. It can be shown that this deformation of Pb^{++} leads to a strengthening of its binding and to a decrease of its free orientation.

3. Flow Lines in a Continuous Melting Glass Furnace as Determined by Cobalt Oxide and Pictured on Color Photographs

By Vernon W. Lenz: Owens-Corning Fiberglas Corporation, Newark, Ohio

The results of a study of glass flow in a direct-fired, continuous melting tank can be used to establish control-testing schedules and tank dimensional relationships. Three primary convection spirals are indicated. Normal convection currents produce good mixing. The methods used in making the study are explained. The use of coloring agent and color photographs as a means of recording the results are presented as a new technique for studies of this type.

4. High-Temperature Concentric Cylinder Viscosimeter for Routine Control Testing

By Vernon W. Lenz: Owens-Corning Fiberglas Corporation, Newark, Ohio

A high-temperature viscosimeter for rapid control testing of production-line glass has been constructed. The apparatus is a modification of Lillie's concentric cylinder viscosimeter, designed to give control-test accuracy and reliability at a rate of speed commensurate with the requirements for this type of measurement. Details of the construction are presented. Calibration of the instrument was made by running a curve in the temperature range of 2150°F. to 2600°F. on a standard glass calibrated at Corning Glass Works. Routine control testing is carried on by obtaining the viscosity at a constant temperature of 2250°F.; it is possible to make one test per hour. Representative curves are presented to show the applicability of the apparatus for control work.

5. Method for Measuring the Fining Times of Glasses

By A. K. Lyle: Hartford-Empire Company, Hartford, Conn.

A method is described for measuring the time required to produce seed-free glass. The results of tests on several glasses are presented to show that the finishing time is an independent property and not a function of viscosity. A procedure is described for estimating tonnage-temperature schedules for continuous furnaces.

6. High-Titania Glasses, I

By Alexis G. Pincus: American Optical Co., Southbridge, Mass., and William Colbert: Glass Science, State College, Pa.

Titania can be introduced into sodium silicate glasses to a much larger proportion (up to 50 weight per cent)) than has been generally recognized. The melts of these titanium sodium silicates are very fluid and form colorless transparent glasses on cooling. Data are presented on several properties of these glasses, such as penetration modulus, thermal expansion, and chemical durability.

7. High Titania Glasses, II

By Alexis G. Pincus: American Optical Co., Southbridge, Mass., and William Colbert: Glass Science, State College, Pa.

High-titania and high-lead glasses are strikingly similar in their optical properties such as refractive index and dispersion. This is also true of the influence of colors of base glasses with a high titania content. Comparative studies are presented on the influence of the addition of titania and lead oxide on several glass colorants.

8. New Law for Flow Processes in Glass

By Richard E. Powell: Princeton University, Princeton, N. J., and Glass Science, State College, Pa.

From the fundamental theory of the flow of matter, it is deduced that the rate of flow of substances like glass should not obey the Newtonian law,

(Rate of flow) = const. (force),

but should rather obey the hyperbolic-sine law,

(Rate of flow) = const. sinh (const. × force).

This latter law reduces to the Newtonian law for small forces.

The hyperbolic-sine law in its integrated form is applied to the annealing of glass and to such other time-dependent processes as the elastic after-effect, the change of refractive index and density with time, and the change of electrical properties with time.

This new theory not only agrees quantitatively with experiment but also provides a single law for the interpretation of various time-dependent phenomena.

9. Supersonics as New Tool for Glass Research

By Hans Mueller: Massachusetts Institute of Technology, Cambridge, Mass.

Glass blocks of any size or shape can be set into elastic vibrations by means of quartz plates driven electrically by a radio frequency oscillator. The vibrations give rise to standing wave patterns which become visible in observation with polarized light. At high frequencies, of the order of 10 million cycles per second, the waves create optical diffraction effects. Studies of these optical effects and of the electrical reaction on the driving circuit furnish information about the elastic, photoelastic, and viscous properties of the glass. Young's modulus, Poisson's ration, Neumann's photoelastic constants, and the damping constant for elastic vibrations are obtained with an accuracy exceeding 1 per cent from a single experiment on a small glass sample.

10. Glimpses of the Glass Division's Twenty-Five Years

By S. R. Scholes: Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y.

The points discussed in this review are as follows: statistics, review of the organization and official personnel, titles of significant papers, and pictures.

11. Factors Which Govern Fluorescence in Glass

By Luke Thorington and Ralston Russell, Jr.: Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., and Alexander Silverman: Department of Chemistry, University of Pittsburgh, Pittsburgh, Pa.

A progress report is given on the study of the influence of minute amounts of substances as inhibitors of fluorescence in glass. Monochromatic light is employed to insure comparable results.

12. Tracing the Flow in Glass Tank Furnaces

By F. L. Bishop, Jr.: American Window Glass Company, Arnold, Pa.

By adding a small amount of a rare earth to a definite portion of batch, the velocity, direction of flow, and amount of surface flow can be determined. These are found by either the resultant slight fluorescence of samples taken at intervals or by the change

(*Continued on page* 192)

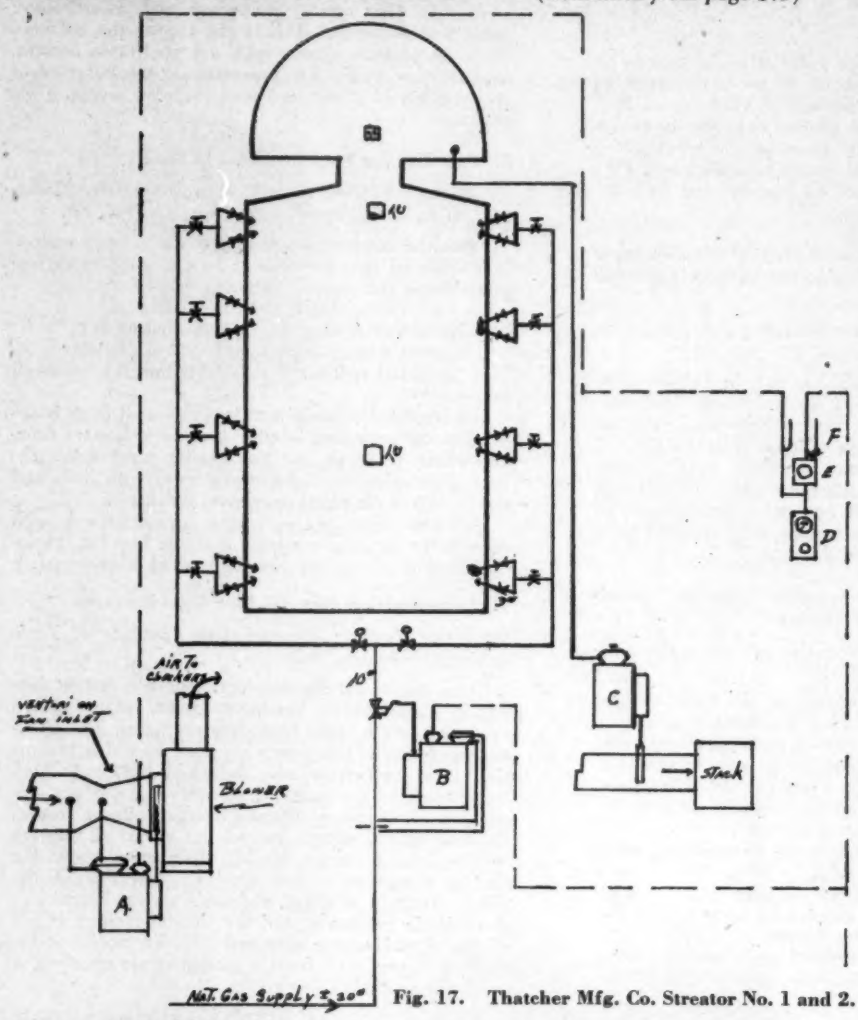


Fig. 17. Thatcher Mfg. Co. Streator No. 1 and 2.

Key A—Air Flow Regulator
B—Gas Flow Regulator
C—Furnace Pressure Regulator
D—Combustion Rate Indicator
E—Fuel-Air Ratio-Handwheel
F—Air Flow and Gas Flow Indicators

ment is shown in Fig. 18.

The furnace pressure indicator and controller, controlling the stack damper motor, occupies the left hand section. The combustion control, gas and air proportioning, is next on the right. Other equipment included thereon is: 1) An electric flow meter for gas having a separate indication of flow rate in CFH, a recording of the rate and static pressure, and a watt-hour meter type flow integrator. 2) Gas burner manifold pressure gauge. 3) 3-point draft indication of stack and flues. 4) 3-point crown temperature indicator-recorder operated again from thermocouples placed in the crown. 5) 2-point checker temperature indicator-recorder operated from a radiation head focused upon the top course of checker brick. This latter also has a pair of red signal lights to indicate a pre-selected limit. 6) Lastly, the batch feeder control panel on the far right hand side of the board. A level indicator, which is mounted on one of the forehearths and flashes a light when a platinum probe touches the glass furnace, is used as a check on the feeding rate.

A further refinement of the preceding combination is

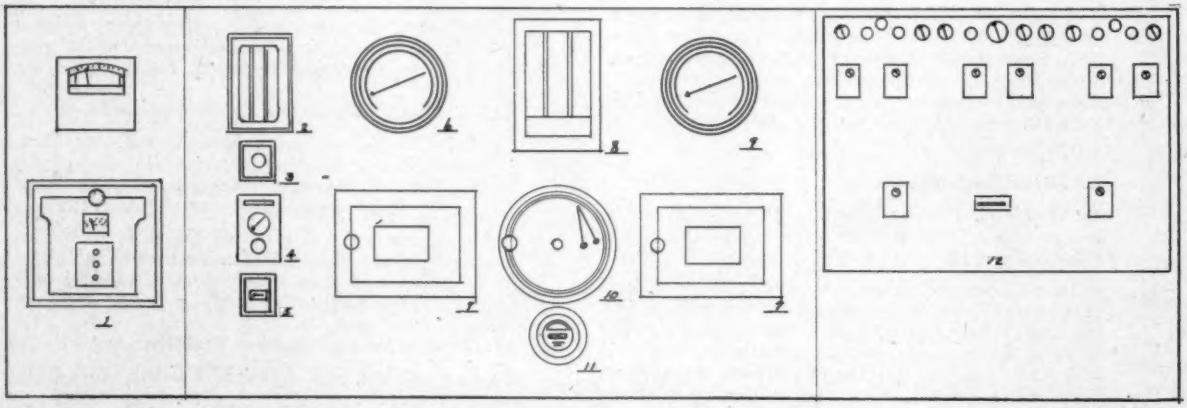


Fig. 18. Combustion Control Panel. Streator No. 1 and 2.

Key 1—1 Furnace Pressure Regulator
2—1 Indicating Manometer
3—Ratio Valve Air Reg.
4—1 Manuel Sub. Panel
5—1 Transfer Valve
6—Flow Indicator, 12" Dial
7—2 Potentiometers
8—1 3-Unit Draft Gauge
9—1 Gas Manifold Press. Indicator, 12" Dial
10—1 Recorder Gas-Flow-Gas Line Press., 12" Dial
11—1 Integrator
12—1 Auto. Batch Feeder Panel

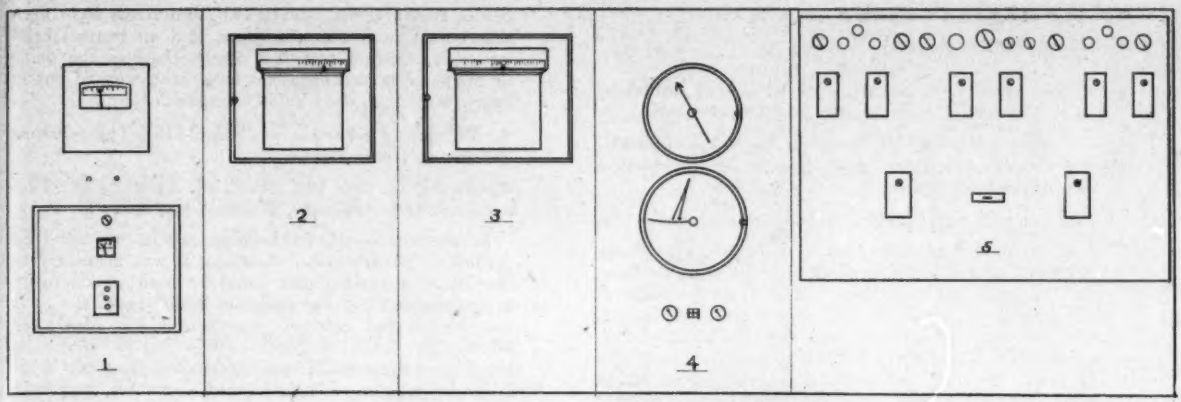


Fig. 19 Control Panel. Furnaces No. 1 and 2.
Key 1—Furnace Pressure Regulator
2—Potentiometer—Flue Couples
3—Potentiometer Crown Couples
Key 4—Combustion Air Regulator
5—Auto Batch Feeder Panel

the incorporation of 5 separate flow controllers, one for each port, which of course ties down positively the heat input to each port. This of course makes the system more complex. It is, however, needed more in the case of a dirty fuel such as Bunker "C" oil where the burner operation is not so clean.

Producer Gas-Firing

Another set-up, this one in use on producer gas-fired furnaces, is shown in Fig. 19. Producer gas of course arrives at the furnace hot, dirty and saturated with tar vapor. Suitable flow metering is not practicable and the furnace control equipment is therefore of necessity more simple.

It need not be emphasized that a great part of the operation of a producer gas-fired furnace, if not the greater part, lies in the operation of the producer plant itself. The operating control equipment on the producer includes automatic pressure regulation on the off-gas, by controlling the steam admitted to the turbo blower. Saturation temperature of the blast air is held automatically by a regulator controlling the exhaust steam injected into the blast. The off-gas temperature (around 1300° F) is regulated by depth of the fuel bed, and the rate of coal feed. Trained operators do a good job on manual control of the latter variable. In some instances, however, the coal feed is re-set automatically by a device which balances blast pressure and off-gas temperature.

At any rate, in good operation the hot raw gas arrives at the furnace valve at uniform temperature and pressure. The simplified furnace control of Fig. 19 comprises: 1) Furnace pressure control. 2) 2-point flue gas temperature recording (gas exit from checkers). 3) 3-point crown temperature recording. 4) Combustion air-weight control, and 5) The batch feeder control. The differential element for the air-weight control is a venturi in the combustion air header.

In the operation of the furnace the air volume is held constant at some pre-selected figure known from past experience to match the fuel gas needed for the specific load conditions on the furnace. Adjustment of the raw-gas valve is then made in accordance with a visual examination of the flame, checked by frequent use of a portable Orsat. Because of the fact that a sooty deposit gradually forms on the surfaces of the producer gas valve,

(*Continued on page* 196)

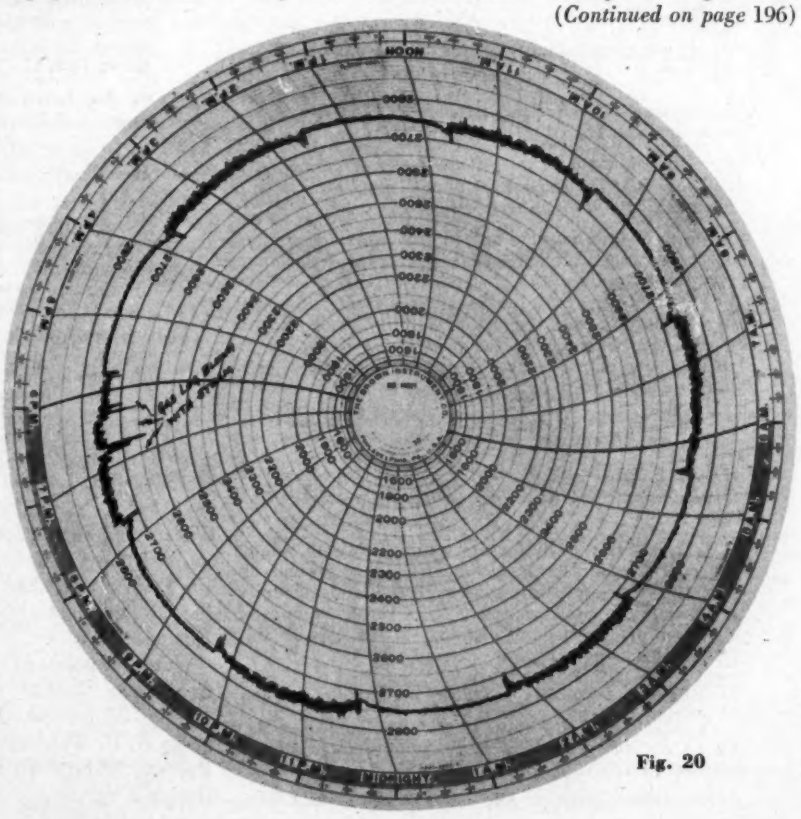


Fig. 20

THE ACS MEETS IN PRINT . . .

(*Continued from page* 189)

in transmission for certain wave lengths of ultraviolet light. Sample results are shown and discussed.

13. Glass Densities by Settling in Heavy Liquids: Water-Bath Apparatus and Method for Production Control in Glass Plants

By Mellen A. Knight: Preston Laboratories, Butler ,Pa.

A rapid and reliable method involving simple apparatus and techniques is described, with specifications for the necessary equipment. This method consists of the settling of lumps of glass in a heavy-liquids mixture by means of uniform heating. Each run is calibrated by including a standard lump among the samples. Similar techniques have proved useful in plant practice. The present method gives quickly more reliable results than does the weighing method utilizing Archimedes buoyancy principle. It is the simplest method of the various sink-float techniques using heavy liquids that have been tried to date. Repeated runs on pieces of glasses show the standard deviation of the method to be less than 0.0001 gm. per cc. The method shows great promise as a means of quickly obtaining density data for quality control work in glass plants.

14. Microstrength of Glass

By H. W. Powell and F. W. Preston: Preston Laboratories, Butler, Pa.

It is shown experimentally that if a minute area of a large piece of glass is tested for tensile strength, the stress supported is comparable with that of fine glass fibers and is some 50 or 100 times the "strength" of the large piece tested in any of the ordinary ways. This can be accomplished by pressing a small steel ball upon the glass surface, and so stressing, in tension, a minute annular zone around the circle of contact.

REFRACTORIES DIVISION PROGRAM

(Partial List)

1. Testing Chrome-Magnesite Brick for Resistance to Iron Oxide Bursting

By Samuel Zerfoss: Department of Ceramics; and H. M. Davis: Department of Metallurgy, Pennsylvania State College, State College, Pa.

The probable mechanism of the iron oxide bursting of chrome-magnesite brick is discussed. An attempt was made to duplicate this effect in the laboratory. Results indicate that the bursting can be simulated in a laboratory experiment provided the atmosphere of the furnace is such that the penetrating iron oxide is rich in magnetite. A test is proposed for characterizing the bursting resistance of various brick.

2. Furnace for Multiple Testing of Reduced Size Samples Under Load

By R. L. Hess and Samuel Zerfoss: Department of Ceramics, Pennsylvania State College, State College, Pa.

A brief summary of American and European testing procedure for refractoriness-under-load is given with special reference to the advantages of using samples smaller than standard size. The construction and operation of a furnace using four 4½- by 2¼- by 1¼-in. samples is described.

3. Effect of a Number of Oxides on Surface Tension of Silicate Melts

By C. R. Amberg: New York State College of Ceramics, Alfred, N. Y.

The surface tension effects of MoO_3, V_2O_5, WO_3, Sb_2O_3, Ni_3O_4, Co_3O_4, MnO_2, UO_2, and As_2O_3 have been determined in a glaze, a glass, and an enamel composition. Certain practical applications in the fields of refractories and abrasives have been worked out in cooperation with the Exolon Company.

4. Physical Properties of Some High-Temperature Refractory Compositions

By Gordon R. Pole and Alfred W. Beinlich, Jr.: Tennessee Valley Authority, Wilson Dam, Ala.

In the course of an investigation which involved studies of pyrochemical reactions, it was necessary to develop a refractory that could be used satisfactorily at temperatures in the range of 1800° to 2200°C. It was found that calcined magnesia (96% MgO) or electrically fused magnesia (98% MgO) could be bonded adequately by mixing sized aggregates with 2.5% by weight of light-burned sea-water magnesia and wetting with a 24° Bé. solution of magnesium chloride. Large shapes of these compositions which had been fired at 1450°C. were satisfactory for use in the temperature range employed.

Small-scale studies of the properties of various refractory bodies showed that composition of relatively pure limestone or dolomite readily hydrated in water even after being fired at 2100°C., which would make them unsuitable for refractory uses. The addition of either silica, alumina, zircona, chromic oxide, or combinations of these oxides to dolomite or lime resulted in refractories stable against hydration.

The inversion of zirconia was reduced appreciably by the addition of 5% magnesia. Zirconium pyrophosphate was found to be highly refractory and to have a coefficient of thermal expansion less than that of used quartz. $BaO{\cdot}ZrO_2$ and $CaO{\cdot}ZrO_2$ were found to be refractory-stable bodies after firing to 2100°C. with no inversion up to 1200°C. and with coefficients of expansion less than that of electrically fused magnesia.

Small- and large-scale tests of a $MgO{\cdot}Cr_2O_3$-spinel composition showed this material to be highly refractory with a low coefficient of expansion; the compound, however, loses its Cr_2O_3 content at temperatures above 1700°C.

8. Insulation in Connection with Refractories—Types and Properties

By Paul G. Herold: Missouri School of Mines and Metallurgy, Rolla, Mo.

A survey and summary of the different types of insulation that are used in connection with refractories installations in current practice are presented. The types of insulation are discussed, bringing out the physical properties and methods of manufacture of typical processes. The paper divides the insulating field as it applies to refractories installations into two classes (1) insulating firebrick and (2) low-temperature insulation. The field of application of both types is discussed as well as a summary of the limitations of each type with respect to service conditions.

PENNSYLVANIA SALT ANNOUNCES NEW APPOINTMENTS

The appointment as of January 1, 1945, of A. S. Woodard as Assistant Chief Engineer has just been announced by the Pennsylvania Salt Manufacturing Company. Prior to his appointment, Mr. Woodard was Senior Chemical Engineer.

Other appointments effective March 1, 1945, in the Company's Central Engineering Department were announced as follows: J. P. Evans, Senior Electrical Engineer; R. R. Walden, Senior Mechanical Engineer; P. F. Dorney, Senior Civil Engineer; and J. W. Dadley, Senior Design Engineer.

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GLASS SCIENCE REVIEWS ONE YEAR'S ACTIVITIES

In March, 1945, the laboratories of Glass Science Research Foundation completed one year of operations. The following resume of their activities appeared under the by-line of Dr. W. A. Weyl, director of the Foundation, in *Mineral Industries* published by Pennsylvania State College:

"In this past year two Pennsylvania companies, the Kopp Glass Company of Swissvale, and the Armstrong Cork Company of Lancaster, joined with the founder companies; namely the American Optical Company, Bausch and Lomb Optical Company, Eastman Kodak Company, and the Pittsburgh Plate Glass Company.

"During 1944, Dr. B. E. Warren of the Physics Department at M.I.T., and Dr. F. E. Wright of the National Research Council, Washington, D. C., accepted appointments as associate members of Glass Science.

"On the 1st and 2nd of August, 1944, the Research Committee, the Research Directors of the sponsoring companies, and members of their Research Staffs held a meeting in State College. Approximately forty persons were in attendance. At this time, Dr. H. Mueller of the Department of Physics at M.I.T., and a collaborator of Glass Science, reported on his work dealing with the application of ultrasonics to the determination of the elastic constants of glass. Dr. R. E. Powell of the Department of Chemistry at Princeton University, also a collaborator of Glass Science, presented his new concept of viscous properties of glass based on absolute reaction rates. A high-light of this meeting was an informal symposium on polishing glass, in which the experts of the several companies exchanged their experiences and reported on their research programs in connection with polishing. Despite the fact that polishing is one of the most complex phenomena encountered in glass technology, this discussion helped to clarify many points of common interest. During the meeting the visitors had ample opportunity to visit the laboratories and get first-hand information of the work in progress.

"W. Colbert has studied the role of titanium on the structure and some of the properties of glasses during this past year. Titania was found to be comparable in many respects to lead oxide. In the course of this work a new ruby glass was discovered. This new glass is distinguished from other rubies, such as gold, copper, and selenium rubies, by the fact that it does not require an additional heat treatment. It is an ionic rather than a 'striking' color.

"In an extensive program on the surface chemistry of glass, Helen S. Williams developed a new method for producing color and fluorescence in glasses by means of the reaction of metal halide vapors with the glass surface. In connection with this program, W. A. Weyl and Helen S. Williams are investigating the reactivity of the alkali, and the possibility of withdrawing alkali from the glass surface. H. H. Kellogg employed a method used in ore flotation to determine the absorption on glass surfaces of ions from aqueous solutions. The work of surface chemistry also called for a method to determine the presence of free metals at a glass surface. This problem was solved by Evelyn C. Marboe through the application of a physical development of the metal nuclei by means of a copper tartrate solution in the presence of formalde-

hyde. The experience gained in this work was later used to study the various methods of depositing metals on glass.

"Dr. S. Zerfoss has already published some of his work dealing with microchemical reactions and is continuing his studies. Recently Dr. R. L. Weber of the Physics Department of The Pennsylvania State College joined Glass Science as a collaborator, and his particular interest is the electrical properties of glass."

CORRECTION

It was erroneously stated in the March issue of THE GLASS INDUSTRY that W. I. Galliher, executive sales manager of the Columbia Chemical Division of the Pittsburgh Plate Glass Company, had been appointed district sales manager for the Division in Chicago.

The correct appointee to this position in Chicago is Walter T. Johnson. Mr. Johnson has been in the Chicago sales office since 1937 and has been serving as acting district sales manager for the past six months. Mr. Galliher's position remains unchanged.

WICKWIRE SPENCER ELECTS VICE PRESIDENT

Announcement has been received of the election of A. G. Bussmann to the position of Vice President in Charge of Sales for the Wickwire Spencer Steel Company. In his new position Mr. Bussmann will have complete charge of all sales and merchandising operations of Wickwire Spencer and the company's subsidiaries.

Mr. Bussmann previously was assistant to the president of Wickwire Spencer. He has been associated with the company since 1930 and was successively Manager of the Wire and Springs Divisions, Sales Manager of the Buffalo District, General Sales Manager and Assistant to the Executive Vice President.

PUERTO RICAN PLANT SUFFERS DAMAGE

It has been reported that the recently completed Puerto Rican Insular Government's glass container plant has suffered fire damage to the extent of $30,000.

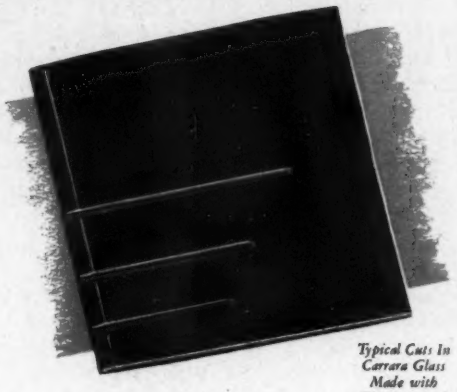
Added to the distressing results of this fire of this Government sponsored plant it seems that the idealistic approach of the Government to labor-management relations has also received a severe jolt.

According to advice from Puerto Rico the $3,000,000 plant which, among other things, was to exemplify the ideal of labor-management relations for government owned industries, has been subjected to a strike of approximately 200 workers who have charged "unfair discrimination" against some workers and difficulties with regard to official recognition of bargaining agents.

Firing of the furnaces ceased when the workers walked out resulting in the inevitable freezing of the glass with its possible complete destruction of the tanks.

• Word has been received that a fire in the main plant of the Specialty Glass Company at Newfield, Pa., on March 19, caused an estimated damage of $250,000. After sweeping through the one-story, quarter-mile long plant, the flames spread across an areaway to a small storehouse filled with cardboard packing materials.

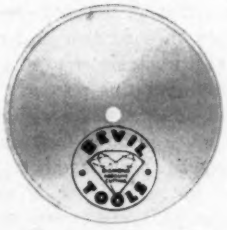
BEVIL
CUT-OFF WHEELS
CUT ALL GLASS



Typical Cuts In Carrara Glass Made with BEVIL Wheel.

...FASTER
...CLEANER
...SAFER

• For cutting tube glass, fragile forms and pyrex, or for cutting or notching the thickest plate or laminated glass, the BEVIL Diamond-Abrasive Cut-off Wheel offers these advantages: (1) It cuts faster. Minimum cutting speeds of 5000 to 6000 S.F.M. are standard. (2) It cuts cleaner. Construction of blade minimizes tendencies to whip, eliminating possibility of damage to material being cut. (3) It cuts safer because patented bonding of body of wheel and rim eliminates possibility of cutting rim pulling loose. In addition, the BEVIL Cut-off lasts longer than the average wheel. This means more and better cuts at less cost. A test will prove it. Try a BEVIL Cut-off Wheel on *your* work.



Bulletin No. 3 describes the BEVIL Diamond-Impregnated Cut-off Wheel in detail, giving sizes and prices. Write for it.

Cryco, Inc.
1516 Mission St., South Pasadena, Calif.
Sales Division of BEVIL CO., Los Angeles
Manufacturers of
BEVIL DIAMOND ABRASIVE CUTTING TOOLS

FURNACE OPERATION AND CONTROL . . .

(*Continued from page* 191)

occasional readjustment of the valve stem is needed to hold the same flow. Even though the method of control is essentially manual, it works very nicely. The distribution of fuel to the various ports of course takes care of itself.

In most furnaces there is enough room between the last port and the bridge to obtain a reproducible optical temperature reading on the bridgewall even with the fire on, by sighting through a peep-hole at that point. This is especially true when sighted in the direction of the flame, in which case there is no flame impingement on the peep-hole. In fact, the furnace atmosphere (free of flame) has no appreciable effect upon the optical reading itself, and the reading obtained under those conditions will be for all practical purposes identical with that shot an instant after the flame is shut off.

Accordingly, a radiation head has been employed in conjunction with an electronic potentiometer to produce in effect a continuous optical reading of the bridgewall, flame or no flame. A four hour chart record of this is shown on Fig. 20. It will be noted that this serves also to locate the flame. With flame going away from the instrument the line is smooth. With flame toward the instrument the line is ragged. As will be noted, however, an average line through the latter is accurate. The radiation pyrometer readings on the smooth part of the cycle check within less than 10° F. with the optical, about as close as two independent optical instruments check. The response is instantaneous, which makes the adjustment of the producer gas valve stem a simple trick. The slightest movement of the latter is immediately reflected in temperature. In fact, we are only one slight step removed from completely automatic operation, wherein the bridgewall reading resets the producer gas valve stem and the checker temperature operates the push-button reversing the valve setting. On oil or natural gas it is not quite that simple unless there is a flow-controller on each port, since the temperature distribution in the furnace could otherwise shift independently of the bridgewall. However, that introduces the back-to-earth question—since the furnace operator is needed anyway, is the extra refinement really necessary?

In conclusion, it has not been the intention in this discussion to convey the idea that all that is necessary is to mount a lot of instruments on a furnace and everything is solved. Instruments require maintenance and lots of it—instruments that are not operating properly are worse than no instruments at all. But with or without control equipment the principal figure in good tank operation is the foreman in direct charge. There have been good substitutes for many things, but experience is not one of them.

• Charles E. Voitle, secretary-treasurer of the National Association of Manufacturers of Pressed and Blown Glassware, died recently in Pittsburgh, Pa. He learned glass working in Wheeling, West Virginia, and after working in glass factories in that state and Ohio, he later was a glass plant manager until 1915 when he became assistant secretary of the Manufacturers' association.

A REPORT ON GLASS FRACTURES . . .

(*Continued from page* 181)

of two disks of equal thickness will be four times the deflection of one disk of double thickness. By cementing the two disks together with the plastic interlayer, the result is intermediate between these two cases and is dependent upon the softness of the plastic.

At the same time, this plastic interlayer cements the glass together so that it does not fly apart when it is broken. This permits vibrations to be set up in the glass which cause the glass surfaces to be alternately in tension and compression. The spiral fracture travels faster on the upper or impacted surface and in nearly every case has crossed the radial fractures after they have occurred. It seems probable then that the spiral fracture is caused when the original compression stress in the impacted surface shifts to tension as the glass rebounds from the impact. The fact that the spiral, especially in Figure 3, is so nearly perfect indicates a nearly perfect adhesion between the plastic and the glass so that the radial fractures interfere very little with stress distribution during the formation of the spiral fracture.

The spiral fracture is much less common than the other types of fracture. It is most likely to occur in laminated glass and is sometimes seen in automobile windows or similar places.

PITTSBURGH SECTION OF ACS MEETS

On March 13 the regular meeting of the Pittsburgh Section of the American Ceramic Society was held at Mellon Institute.

After a short business session George Bair of the Research Department of the Corning Glass Works gave a talk entitled "Glass—The Custom-Built Material," covering the various properties which can be incorporated into different glasses. He had a collection of specimens and a number of slides with him to further explain his talk.

The April meeting is scheduled for Tuesday, April 10 and on Friday, May 11, an afternoon session is scheduled at Mellon Institute at which time a number of technical papers written for the Annual Convention will be presented.

BALL BROTHERS PLACED ON URGENCY LIST

Ball Brothers Company of Muncie, Indiana, recently received word that it had been placed on the national urgency list as a War production plant. It is the only industry in Muncie so classified.

The company is now making battery shells for the military and has been asked to step up production to one hundred million shells per month, doubling what it has been doing. The concern recently purchased a plant at Greencastle, Indiana, which will probably help step up production as all the space at the Muncie plant is being used to capacity.

BUY WAR BONDS

207.81 Tons of Glass Per Square Foot Per Life!

SEVERAL months ago we reported the operating data of a Corhart Electrocast tank melting flint bottle glass, which had finished its first run, and was then operating on the second run of its campaign. As promised at that time, we are now reporting to you the outcome of the completed *two-run* campaign.

You may remember that on the first run, the tank produced 142.18 tons of glass per square foot. ***On the second run this tank produced 65.63 tons of glass per square foot, for a record of 207.81 tons of glass per square foot per life.***

The operating data for the complete two run campaign is as follows:

Melting Area 440 Sq. Ft.		Total Days Life	Total Operating Days	Idle Days	Total Tons Flint Glass	Tons Glass Per Sq. Ft. Per Life
1st Run	7/3/41 To 11/11/43	860	844	16	62559.19	142.18
	DOWN PERIOD			13		
2nd Run	11/24/43 To 11/15/44	357	352	5	28878.95	65.63
	Total	1217	1196	34	91438.14	207.81

At the end of the first run the Corhart Electrocast sidewalls and throat were left in place for the second run by overcoating at the metal line when repairing the superstructure. At the end of the second run, which was terminated for reasons other than failure, it was found that the overcoating on a portion of the sidewalls, and on the complete bridgewall, had not been needed for this complete campaign. In fact, the operator of the unit has reported that, in his opinion, much additional life still remained at the end of the second run.

If you have never fully investigated the possibilities of Corhart Electrocast balanced tanks, we would appreciate an opportunity to discuss the matter with you.

Corhart Refractories Company, Incorporated, 16th and Lee Streets, Louisville 10, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

DENSITY AND SPECIFIC GRAVITY . . .

(*Continued from page* 175)

Calculations:

s, d	(6) Weight of glass in water at T° = (2) — (4)	13.2206 gm.
s, d	(7) Loss of weight by glass in water = (1) — (6) (Equals weight of water displaced.)	8.7941 gm.
s	(8) Uncorrected T°/T° Specific Gravity = (1)/(7)	2.5034
d	(9) Uncorrected Density at T° = (8)x(5)	2.4964 gm./cc.
s	(10) Air-buoyancy Correction for Specific Gravity	—0.0018
s	(11) Buoyancy-Corrected T°/T° Specific Gravity	2.5016
d	(12) Air-buoyancy Correction for Density	—0.0018 gm./cc.
d	(13) Buoyancy-Corrected Density at T°	2.4946 gm./cc.
s	(14) Temperature Correction for Specific Gravity (Read from Figure 1 for T° temperature.)	—0.0022
s	(15)* True 20°/20° Specific Gravity	2.4994
d	(16) Temperature Correction for Density (Read from Table II for T° temperature.)	+0.0003 gm./cc.
d	(17)* True 20° Density	2.4949 gm./cc.

(B) Heavy-Liquids Methods

Method: In the various sink-float techniques utilizing heavy-liquids mixtures, the unknown glass is compared with a standard glass of known density. This is done most conveniently through regulation of the temperature of the mixture of a lighter-than-glass liquid and a denser-than-glass liquid. The ratio of the liquids is adjusted according to the density of the glass being tested, and then is not further changed during the run. The temperatures at which the unknown and the standard correspond to the density of the liquid are determined. Each sample may be balanced in the liquid at its respective temperature, or the system may be heated, or cooled, uniformly and the temperatures recorded at which the samples pass a reference level in the tube of liquid. The latter technique, the Settling Method, is described in detail in a current paper by this writer.** In plant practice the standard glass is usually a piece of typical production selected from recent, homogeneous (cord-free) ware.

Data: The data in these techniques consist of the following:

(1) The net density change with temperature, $(dD/dT)_{NET}$, of the liquid relative to the glass. This equals the difference between $(dD/dT)_L$ for the liquid and $(dD/dT)_G$ for the glass, $(dD/dT)_L - (dD/dT)_G$. For any appropriate pair of liquids this factor is a constant for all the pertinent mixtures.†

(2) The density of the standard glass, D_s, at the standard temperature, 20°.

(3) The reference temperature for the standard glass, T_s.

(4) The reference temperature for the unknown, T_x.

Thus (1) and (2) are standard for the system, while (3) and (4) must be determined on each run.

The following are typical data:

s, d	(1) $(dD/dT)_{NET}$	—0.00171 gm./cc./°C.
s, d	(2) D_s at 20°	2.5067 gm./cc.
s, d	(3) T_s	29.43°
s, d	(4) T_x	26.82°

Calculations:

Use of the following equation, with careful attention to algebraic signs, insures that the densities will be calculated correctly.

$$D_x = D_s + (T_x - T_s)(dD/dT)_{NET} \quad (5)$$

where D_x = density of the unknown at 20°

Thus, for the illustrations above:

s, d (5) $D_x = 2.5067 + (26.82 - 29.43)(-0.00171)$

$= 2.5067 + (2.61)(0.00171)$

$D_x = 2.5112$ gm./cc. at 20°

Therefore, the unknown glass has a density equal to 2.5112 gm./cc. at 20°. If the 20°/20° specific gravity is desired, the density of the glass at 20° is simply divided by the density of water at 20°, 0.9982 gm./cc., thus:

s (6) 20°/20° Specific gravity $= \dfrac{2.5112}{0.9982} = 2.5157.$

Summary

Each density or specific-gravity value must be expressed so as to represent the glass at some known temperature if it is to have significance in comparison with other data. A convenient and common standard temperature is 20°C; the values reported from this laboratory give 20°/20° specific gravities and densities at 20°. From data obtained at various temperatures of measurement, these values corresponding to this standard temperature of 20° can be conveniently and quickly found; use of the factors and calculations presented above gives these values for all commercial, "soda-lime-silica" container glasses.

The densities of these glasses change linearly with temperature at room temperatures. These densities decrease by 0.00007 gm./cc. for each degree centigrade increase in temperature. Standard values at 20° can be quickly found by means of the corrections given in Table II for temperatures of measurement from 10° to 50°.

The change of specific gravity with temperature is not linear. For temperatures of measurement, T°, ranging from 10° to 50°, Figure 1, or Table III, gives the corrections for the conversion of the T°/T° specific gravities to the standard 20°/20° values.

The applications of these corrections are illustrated in detail in the section on Sample Calculations.

*If the buoyancy correction is omitted, the final value will be 0.0018 units greater than these true, absolute values.

**Mellon A. Knight, "Glass Densities by Settling in Heavy Liquids—Water-Bath Apparatus and Method for Production Control in Glass Plants." Offered for the Annual Meeting Program, April, 1945, The American Ceramic Society.

†The value of dD/dT for the liquids used in this laboratory, a-bromonapthalene and s-tetrabromoethane, is —0.00178 gm./cc./°C. Combined with the —0.00007 gm./cc./°C value for container glasses, this yields a factor of —0.00171 gm./cc./°C for these liquids and glasses.

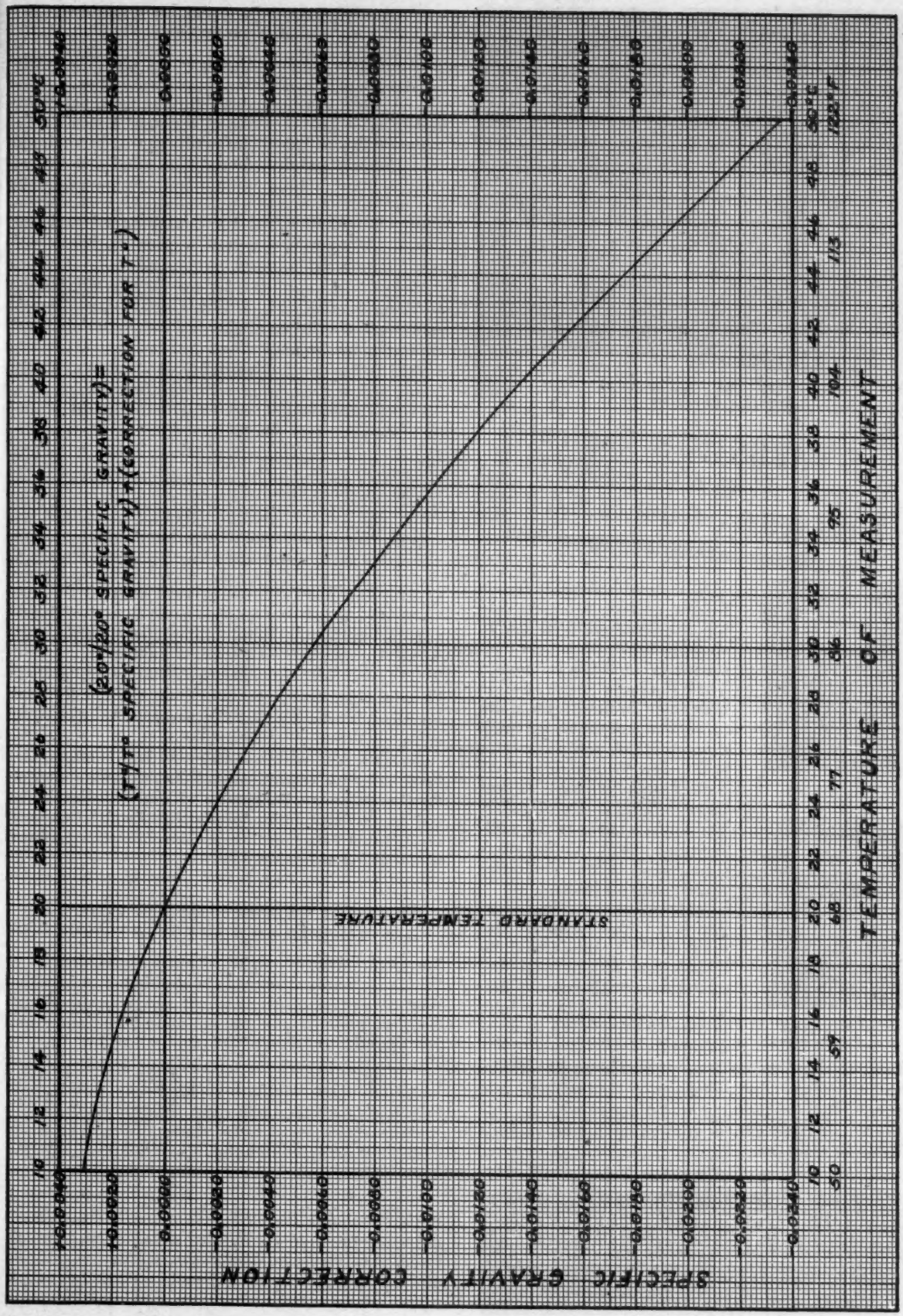

TEMPERATURE OF MEASUREMENT
STANDARD TEMPERATURE
SPECIFIC GRAVITY CORRECTION
(Observed Specific Gravity) + (Correction for t°) = (t°)Fo Specific Gravity

Fig. 1.—Calculation of Density and Specific Gravity . . .

Automatic
COMBUSTION Control
FOR A GAS-FIRED
GLASS FURNACE

HAYS
AUTOMATIC TANK
PRESSURE CONTROLLER

HAYS
AUTOMATIC GAS-AIR
RATIO CONTROLLER

FOR most efficient results two controls are used. See the installation sketch above showing instruments and connections. The Hay's Automatic Tank Pressure Controller is connected to the crown of the furnace and actuates the stack damper. This control operates with a few thousandths of an inch of water pressure, so that there is always an accurate relationship between the pressure in the tank and the stack draft, which is controlled within very narrow limits.

A Hays Automatic Fuel Gas-Air Ratio Controller is also used which, by measuring the intake flow of gas and air, maintains at all times a definite air-gas ratio, and a high percent of CO_2 in the stack or exit gases.

Each unit performing its own function works with the other to produce the best furnace temperature and pressure, and the most efficient atmosphere.

For oil, the same system applies, but the instruments are a little different.

For Full Information Send for Bulletin 43-552

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

BALL BROTHERS TO HAVE NEW RESEARCH DEPARTMENT

Although Ball Brothers Company has always had testing laboratories and testing departments where experimental work has been done, the company has never maintained a separate research department. Such a department is now being developed and will be equipped to do research and development work on glass packages, closures, food packing, and processing methods for both commercial and domestic packaging and preserving of foods. Its objective will be to work on all problems that could contribute toward keeping Ball Brothers' products on a high standard.

The new department will be headed by Fred H. Dellwo as Manager and Karl L. Ford as Chief Research Technician, both men being admirably fitted by training and experience for the job.

Fred Dellwo is a graduate of the University of Washington with a Bachelor of Science degree. He has been associated with the Research Departments of the American Can Company, the National Canners' Association, and a number of other organizations including packers of seafood, vegetables and baby foods. He has had experience in both dehydration and freezing of foods, so that he is familiar with these fields of food preservation.

Karl Ford is a graduate of the Massachusetts Institute of Technology, with a Bachelor of Science degree in Chemical Engineering. Upon his graduation he became an instructor and did research work at M.I.T. for two years, after which time he went to the Bureau of Standards in Washington, D. C. Following this, as Research Technician for the Glass Container Association, with Dr. S. H. Ayres, he set up a research laboratory for the Glass Container Association in New York, and for the next fourteen years worked on problems connected with packaging and processing foods in glass.

Recently, until his employment by Ball Brothers, Mr. Ford had done consulting work in the construction of the Grange League Conferation of Waterloo, New York, and set up laboratories for Hartford-Empire Company to work out some wartime problems in glass package handling and processing.

ARMY-NAVY TERMINATION REGULATION AVAILABLE TO WAR CONTRACTORS

The Joint Army-Navy Termination Regulation is a "must" for war contractors to be used in the rapid settlement of war contracts. A recent survey disclosed that less than 40 per cent of the war contractors circularized had availed themselves of this publication.

It is *imperative* that contractors holding war contracts be placed on the mailing list for the Regulation and all subsequent changes. There is no charge for any of this material which can be acquired by request to the Joint Army-Navy Distribution Center, 90 Church Street, New York City.

● The Pittsburgh Plate Glass Company has announced the appointment of R. W. Mothershed as manager of the Atlanta branch of that company, and the transfer of Felix T. Hughes from that post to Pittsburgh as assistant manager of the plate glass sales department.

REORGANIZATION IN OWENS-ILLINOIS SALES STAFF

The glass container division of Owens-Illinois Glass Co., has announced the redistribution of duties of some of the principal members of the sales staff, effective as of March 15, and the appointment of a sales policy committee. The new plan divides the company's sales development responsibilities into three broad groups—drugs, foods and beverages.

E. F. Bertrand, now on leave with the WPB, has been named sales manager to the sales division serving the drug industries, which will cover all drug, chemical and household items; R. E. Delaphane becomes sales manager to the beverage group, including carbonated and alcoholic beverages and continues his responsibilities in closures and plastics, and E. A. Hildreth will be sales manager to the food divisions covering both processed and prepared foods.

NEW REPRESENTATIVE FOR CHAS. TAYLOR

Announcement has been received that The Chas. Taylor Sons Co., Cincinnati, has appointed Mr. T. H. Palmer of The Fire Brick Supply Co., Minneapolis, Minnesota, as their exclusive representative in Minnesota, North and South Dakota, and Northwestern Wisconsin.

The Fire Brick Supply Co., will serve as distributors of P. B. Sillimanite and Zircon Refractories manufactured by The Chas. Taylor Sons Co.

STAUFFER CHEMICAL TO EXPAND SULPHURIC ACID PLANT

Stauffer Chemical Company recently announced plans to expand their Hammond, Indiana, Sulphuric Acid plant to meet accelerated wartime demands and to insure sufficient tonnage for post-war activities.

Officials of the company said that this increase in capacity will require considerably more floor space and a permanent structure is in process of erection and should be completed about July 1. They also stated that Stauffer's policy of shipping sulphuric acid in tank cars, drums and carboys to the mid-western area will not be interrupted or altered.

NEW DIRECTOR NAMED FOR LACLEDE-CHRISTY

Don N. Watkins has recently been elected to the Board of Directors of the Laclede-Christy Clay Products Company of St. Louis to succeed A. H. Killinger.

Mr. Watkins has been President of Steel Publications, Inc., since 1927. From August 1, 1941, to October 30, 1942, he served with the War Production Board as Chief of Refractories and Fluxes, Chief of Steel Plant Construction and Chief of Steel Plant Facilities Section of the Steel Branch. He also served as executive consultant to Henry J. Kaiser Company on construction, operations and sales of Kaiser Iron and Steel for a period of approximately six months.

• The Optical Society of America has announced that their annual meeting scheduled for April 12-14 in Cleveland has been postponed at the request of the War Committee on Conventions.

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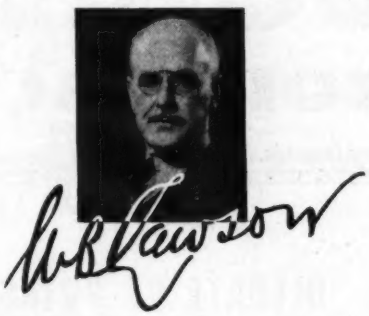

Merchants, Manufacturers' Sales Agents, Industrial Chemicals and Nonferrous Metals, Warehouse stocks in New York, Cleveland, St. Louis and Detroit.

Distributors for American Potash & Chemical Corp. (Borax and Boric Acid); Darling & Co. (Oleic and Stearic Acids); Duquesne Smelting Corp. (Nonferrous Metals, Zinc Dust); Ferro Drier & Chemical Co. (Driers and Metallic Soaps); Lindsay Light & Chemical Co.; Merck & Co. (Laboratory Reagent Chemicals); Philadelphia Quartz Co. (Silicates); Stauffer Chemical Co. (Sulphur); Tennessee Corp.; Virginia-Carolina Chemical Co.; Wyandotte Chemicals Corp.; and others.

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HANDBOOK of the GLASS INDUSTRY

• The first printing of the Handbook of the Glass Industry has become exhausted and the continued demand for copies has resulted in a second binding.

Through printing economies obtained by a lowered unit cost in the second printing of the Handbook we are able to offer this useful, ready reference glassman's handbook at the *reduced price of $3.50 per copy.*

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HARTFORD-EMPIRE 74 . . .
(*Continued from page* 176)

value of the container some discrimination between seed and checks was considered to be desirable. It may be observed, however, that some glass manufacturers are not adverse to having seed rejected as this has a tendency to tone up the operation of the melting end and consequently results in higher quality ware being produced throughout the plant.

In determining the desired function of the Hartford 74 Check Inspector careful observation of the reflected light from a check and the scattered light from a seed led to confining the reflected ray to a narrow, vertical shaft. This allowed practically all the reflected light from the check to enter the cell but cut down the intensity of the scattered light from the spherical seed to below a threshold resulting in such discrimination between checks and seeds that only the larger seeds were rejected.

There is another type of defect associated with the finish that the check inspector will reject without discrimination between it and checks. This is the vertical plunger scratch on the inside of the finish. In itself this is not inimical to vacuum sealing, or functionally objectionable but observation of the trend of manufacture shows that when the plunger scratches become deep they will soon imitate operational trouble at the forming machine. Therefore, it is deemed desirable to reject plunger scratches as a means of toning up forming operations.

It should be noted in this connection that while a plunger scratch can always be distinguished from a check through a reasonable amount of examination by anyone thoroughly familiar with glass defects, ordinary packing room personnel, particularly those available under today's labor conditions, are far from infallible.

The Hartford 74 Check Inspector actually has two component parts—a turret type revolving mechanism having eight carriers into which jars are loaded automatically as they come from the lehr and the "brain" or inspector—an electronic and optical unit, utilizing the electric eye.

When the equipment can be made commercially available, the advent of which is contingent upon war conditions, it will include a conveyor system designed to handle the containers from the lehr to the automatic inspector and thence to the packing table.

In the meantime, the check inspector has undergone experimental trials under actual commercial conditions at the Diamond Glass Company in Royersford, Pennsylvania. A carload of food jars were inspected and sorted by this machine. These jars were found by the packer to give very much better results and after being put through the regular processing and carefully re-inspected under a method which has always been employed by the packer the loss from finish checks was found to be only one jar out of a carload of approximately 480,000 containers.

• Appointment of Thomas H. Truslow, Jr., as sales promotion manager of the consumer products division of Corning Glass Works has been announced by the company. A former Army major, Mr. Truslow recently received his honorable discharge after two years overseas.

TO DECORATORS ONLY:

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At The O. Hommel Co., every step of our process is controlled to make sure that Hommel colors and squeegee oil . . . even in these days of war . . . will bring you satisfied customers and fast production. From the time the raw materials enter the mill until the finished color and squeegee oil is shipped, laboratory watchfulness never ceases . . . every single manufacturing step is rigidly controlled. And finally, the finished color and squeegee oil must pass the toughest test before it is ready for delivery to you.

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